ROCKY MOUNTAIN VEGETABLE GARDENING GUIDE

Cheryl Moore-Gough & Robert Gough

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To Rocky Mountain vegetable gardeners—my colleagues, students, and inspiration. You spend three months each year in a blaze of activity, planting, watering, fertilizing, nurturing, and harvesting. You battle wind, hail, insects, and weeds, in order to produce the freshest, tastiest, and most nutritious vegetables for your families. You experiment with heirlooms and hybrids, and sometimes even save your seeds from year to year. You eat what you can consume fresh then freeze, can, pickle, and dehydrate until three in the morning. And then it's over. Nine months of snow and ice, gray skies, and slippery roads, during which time you can still enjoy the fruits of your summertime labors, read books and catalogs, search the Internet, and plan for your next vegetable garden.

This book is for you.

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THE VEGETABLES

Acknowledgments

For your contributions to this edition of *Rocky Mountain Vegetable Gardening Guide*, a big thank-you to Kristin Braaksma, Karen Carter, Lavon Carter, Bill Gilbert, Kathy Gillin, Andra Spurr, Dan Spurr, and Dr. Stephanie Walker.

"Dr. Bob" Gough, my late husband, passed into the big vegetable garden in the sky in 2011. Many of the words in this book are his, and I could not bear to omit him as coauthor. I owe him a tremendous debt for the inspiration he was to me and my writing while we were together, and for the fact I found someone as enthusiastic about vegetable gardening as I am.

To the good folks at TwoDot Books—Courtney Oppel, Julie Marsh, Joanna Beyer, Kathy Brock, and Chris Jagger—thank you for making this happen.

Welcome to Gardening in the Rockies

Are you tired of boring grocery-store carrots and tasteless tomatoes? Are you done with spending your food dollars on less-than-ideal greens? Would you like to pick your own, juicy, mouthwateringly delicious tomatoes, harvested at the peak of flavor? Would you like to enjoy your children's eager squeals as they taste freshly picked sugar snap peas (full of natural goodness!)? Do you love to be out in the beautiful Rocky Mountain air and sunshine? Then join me as I help get you started vegetable gardening!

There's nothing like growing your own vegetables *your* way! You may choose to garden organically, minimizing chemicals to which you may not want your family exposed. You may choose to use modern technology and chemicals. Or, you might decide to just use the least toxic methods everywhere, whether it is handpicking fat tomato hornworms, spraying insecticidal soap on aphids, or using that great old Christmas-sounding weed control . . . hoe, hoe, hoe! There are many ways to garden successfully, even in our short seasons. How you garden is *your* choice; you have the control when you grow your own vegetables!

Another benefit of growing your own vegetables is the increase

in selection due to the wide variety of edibles offered in today's gardening catalogs, like yellow-fleshed watermelons, "black" tomatoes, and blue potatoes. Did you ever fall in love with an exotic plant while on vacation? Bob and I did—we ate callaloo in Jamaica, found some seeds in a catalog, put them in the ground, and watched them *not* grow. While we really didn't expect a tropical plant to thrive in Montana, it was a fun experiment. But there are plenty of "good eats" available to gardeners that just aren't on store shelves, or if they are, you'll pay a ridiculous price for them!

This brings to mind one more point—a packet of seeds that will result in hundreds of plants, costs far less than the equivalent number of vegetables purchased at the market. Of course, you have to figure in water, fertilizer, and your time when you consider cost, but many gardeners feel they are getting quite a bargain with their garden.

A beginning vegetable gardener often doesn't realize just how limited our Rocky Mountain growing conditions are. She just wants help "getting growing," and a good gardening book can do just that. An experienced vegetable gardener transplanted into the Rocky Mountain region may be tempted to throw in his trowel in despair or, on the other hand, will find resources to help get familiar with his new locale and its limitations, stick out his jaw and defy our diverse and challenging conditions, and grow abundant food for his family and to share with others.

As gardeners and authors, my late husband and coauthor of the first version of this book and I relate to each of these circumstances. Dr. Bob started gardening at the age of 5 in Rhode Island. He transplanted to the Rocky Mountain region and had to modify his gardening to the adverse climate, rocky and alkaline soils, and shorter growing season found here. I started my gardening experience in the Gallatin Valley of Montana and never knew anything other than the unexpected summer snows, strong winds, hail, and tough weeds; I learned how to garden in these conditions.

Each of us would have welcomed a book such as this, but what was available at the time was much too general and often not applicable to our growing conditions. While trial and error work, it helps to have good, solid guidance right from the start. Whether you are a beginning gardener, just starting down the path of producing your own food, or have a few plots under your belt, the information found here is meant to help you, the eager reader,

understand how to go about vegetable gardening in this tricky region. References are included if you need further information and a handy glossary to define less-than-familiar terms. Don't be intimidated by gardening in the Rocky Mountains; it's fun and very rewarding!

Let's talk about how this book can help you. The first section is divided into helpful general gardening topics that apply to our region. The second section discusses in detail the specific vegetables that will grow well in the Rocky Mountain Region. Here then is an overview of those chapters and what you can expect to learn from them.

The Lay of the Land: The Rocky Mountain Region

Knowing your growing season is essential for good gardening, but that's not an easy task. You can go online to find your US Department of Agriculture (USDA) hardiness zone, or call your local county extension office, but the USDA hardiness zones speak *only* to the average cold temperatures of a region. Since most vegetables are grown as annuals, this information is of little consequence. More important is the length of the growing season, in other words, the number of days between the average last killing frost of the spring and the average first killing frost of the fall. You'll find this information for selected Rocky Mountain cities within these pages. Keep in mind, the "average" dates are usually plus or minus 2 full weeks. In many areas of the country, the USDA hardiness-zone designation can be roughly translated into length of the growing season, but not in ours. Sometimes the colder the winter, the longer the growing season, as is the case for the upper Yellowstone areas of eastern Montana.

Get to know your resources and use this book! Read the entries for each vegetable in the second half of the book, and pay attention to recommended varieties' maturity dates. Ask your neighboring gardener friends when they usually plant certain vegetables and how long your growing season is. Call the local extension office, but ask the right questions; don't ask what zone are you in, rather, how long a growing season you can expect. Join a local gardening club! Never plant vegetables whose maturity dates are longer than your growing season, with the possible exception of root crops like parsnips and salsify, which can take the late-season cold

temperatures and even sweeten in them, or experimental crops you just have to try just this once, like okra.

Join a gardening club!

This chapter also addresses soil types. Rocky Mountain soil is varied. While some areas have fertile, moist soils, others have soils that are dry, rocky, and compacted. Adapting your gardening techniques to your soil type is a must. You'll soon learn how!

Planning Your Garden

How big a garden should you plant? Most of us have planted too much, and the garden becomes an unenjoyable chore. I'll help you determine your ideal garden size, how many feet of each plant to sow, and how to place your plot to maximize sunlight. Mapping your general garden layout in advance of planting will help you avoid disappointment . . . and extra work!

Different Strokes for Different Folks: Cropping Methods

There are many ways to garden, and you'll have plenty of ideas after reading this chapter. Rotating vegetables breaks insect and disease cycles in your plot and avoids depletion of nutrients by those vegetables with heavier feeding requirements. Intercropping—

planting two or more vegetables together—can boost your yields and biodiversity using plants that complement each other, for instance, plant deeply rooted veggies among more shallowly rooted crops. If you have an insect problem, figure out that insect's preferred vegetable treat, so, if you have the room, you can plant a "trap crop" to lure them away from others.

Do you have limited planting area but big ideas for producing food? Raised beds, trellising, and other smart space savers are just the ticket.

In addition to these basics, you'll find which vegetable seeds may be sown directly to the garden and which should be started as transplants, and you will even be able to start your own transplants to get a jump on the growing season! You'll learn options for weed and pest control, extending our short growing season, watering efficiently, and how to get to know your soil. Understanding when and how to harvest and store your vegetables is another essential topic. In other words, you'll be all set for a great gardening experience!

Seeds or Transplants?

It's surprising, but true: Many gardeners purchase vegetable seeds based on the photograph in the catalog or on the packet. I'll show you how to read seed packets and extract the essential information you need for a successful Rocky Mountain garden!

Do you want to save seeds from the vegetables you grow, or do you prefer to grow vegetables that have been hybridized and bred for certain characteristics, like good freezing, canning, and storage qualities? It's exciting to save your own seeds year to year, but if you save them from a hybrid plant (designated on the label as F_1 or hybrid), you will be disappointed. It has to do with the genetics of the seeds, not anything you did or could have done to prevent the change in plant in the second year. I'll show you how to tell which seeds "come true" and which ones don't.

Soil Fertility

Getting to know your garden soil is a must! If you have compacted soil, for instance, it's hard as a rock, and your carrots will be split and funny looking, *if* they can even penetrate the soil. Soils that are compacted generally have more clay present than the other two

mineral elements of soil, sand and silt. The relative proportions of these three soil components determine your soil texture and affect greatly what you can plant, how you should plant it, water it, and fertilize it.

It's important to have a general knowledge of the pH or acidity level in your garden. Soils in the Rocky Mountain region are generally higher in pH than those in other parts of the country. Some soil nutrients are less available at certain pHs, and you need to know how to apply fertilizer, in correct amounts, to remedy that.

After reading this chapter, you'll know how to get to know your soil.

Other Great Ideas

In addition to these basics, you'll be comfortable knowing which vegetable seeds may be sown directly into the garden and which should be started as transplants, and you will even be able to start your own transplants and use other techniques to get a jump on the growing season! You'll learn when and how much to water, options for weed and pest control, and techniques for extending our short growing seasons. Knowing how and when to harvest and store your vegetables is another essential topic. In other words, you'll be all set for a great gardening experience!

The Vegetables

And lest we forget, the stars of this book have an entire section of their own, which discusses in detail vegetables that will grow well in the Rocky Mountain Region.

Vegetables are plants that may be perennials, like asparagus and rhubarb, returning each year to welcome you back to the garden; annuals that are grown from seed each year and produce seed for the following year; or biennials like cabbage and parsnip that take 2 years to form seed, though they are grown as annuals for food. You'll soon discover why knowing this information is important to you.

Each vegetable profile has a set of "quick tips" that tells you exactly what you need to know to grow that crop successfully. There are many important tidbits here, such as how deeply to plant the seed, how closely to plant within a row, how far apart to place the rows, and how much produce you can expect to harvest for the

number of feet in your row.

The vegetables are noted as cool season and warm season for a very good reason: In the Rockies, we must not plant warm-season crops like corn or beans too early or the seeds will rot in the ground! Cool-season crops like peas will stop producing when the heat of summer hits and will be a bust if planted too late. This piece of information alone can make or break your garden. Plant cool-season crops early, and buy a soil thermometer to know when it's safe to plant your warm-season crops.

And finally, a word of encouragement: If a transplant like Dr. Bob and a novice like me can grow vegetables successfully in the Rocky Mountain region's challenging conditions, so can you!!!

Enjoy your garden. Allow your children to pull weeds and graze the peas and carrots. Give them the gift of knowing where their food comes from and of eating fresh, nutritious, and *really* tasty vegetables.

I'll see *you* in the garden!


The Garden

Chapter 1

The Lay of the Land: The Rocky Mountain Region

Our six-state area covers more than a half-million square miles from the flats of the western Great Plains west beyond the alpine peaks of the Rockies, making a detailed discussion of all the subtleties of climate and soil variations impossible in a single book. But we can give you a state-by- state general discussion of soils, precipitation, temperatures, and storms that will impact *your* garden. Ours is a region of extremes. Gardening here is not easy, and therein lies the challenge. The most important issue is elevation, for elevation has the most significant impact on temperature, precipitation, and local weather conditions. Indeed, due to the elevation of some Rocky Mountain locations, there is literally *no* growing season there. In others, there can be as much as a 30–40°F difference between day and night temperatures, and the intense sunlight can burn plant foliage and rapidly dry soil and leaves. Soils become thinner at higher elevations and hence less suitable for vegetable gardens.

You'll quickly learn to amend and enrich your garden soil to be successful, but it's important to know the type of soil in your garden to determine what inputs are needed.

Gardeners can expect about an 11°F reduction in temperature for every 3,300-foot increase in elevation. Even small differences in elevation can cause marked differences in growing conditions. For example, Bob and I used to live 6 miles south of Bozeman, Montana, where our garden was about 200 feet higher than Bozeman proper, yet our growing season was about a month shorter than in town. Part of the reason was the heat-sink effect of towns, but another part was the small difference in elevation.

This chapter includes tables for each state in the Rocky Mountain region containing elevation, average growing-season length, and other important information for selected cities within each state. Not all cities lie in the Rocky Mountain region, but they are included for comparison purposes. Length of season is based on the average number of days between last and first frosts of the season (32.5°F). You can use these figures to estimate the length of your garden's growing season pretty closely, but remember, "average" can mean plus or minus weeks in either direction!

The extreme variability in growing-season length over the years is a result of the highly variable climatic conditions that make our gardens such a challenge.

After you have pondered this information, you will have a good, general idea of what your garden conditions will be like, but only after you have recorded your own conditions for 5 or 10 years will you have a really good idea of how the season unfolds for you. Rely on your gardening neighbors for good advice on planting dates and varieties that work best in your area. Then spread your wings and try something new. My original mentor told me, "Stay away from head lettuces—they don't work here," so I did—at first. He was set in his gardening ways, while I discovered new varieties that work very well here.

Colorado

Colorado is the highest state in the United States, with an average elevation of 6,800 feet. About 40 percent of the state is High Plains, which slope gently higher as you move westward from the eastern border at elevations of 3,350 to 4,000 feet, through the Front Range. The High Plains are usually hot on summer mornings and cool during an afternoon thunderstorm. Those thunderstorms can sometimes be severe, and the hail they contain will destroy gardens in minutes. The daily maximum summer temperature is about 95°F at elevations below 5,000 feet, but it cools at higher western elevations. There are wide variations in temperatures within short distances. For example, the difference in average annual temperature between two gardens only 90 miles apart can be equivalent to the difference in that temperature between Florida and Iceland.

About 85 percent of the annual precipitation falls in summer. Gardeners in the northeastern areas enjoy a respectable growing season of about 140 days, those in the southeastern areas an even longer season of about 160 days, and the fortunate few in the extreme southeastern corner of the state relish their 180-day seasons.

About 200 miles west of the eastern border lie the foothills, with elevations of about 7,000 to 9,000 feet. Gardening here becomes very challenging, with an average July temperature of 60°F and daily highs in the 70s and 80s°F. Nights are particularly cool all summer long, limiting your vegetable selection. Cool-season crops will do well, but warm-season crops will be more of a challenge.

Beyond the foothills lie the mountains, rising from 9,000 to 14,000 feet, and beyond them the high plateau that extends to the western border at elevations above 10,000 feet. While there may be some gardens in the low western valleys, much of the mountainous area simply does not have a long-enough growing season to make it worthwhile. Nights are so cool above 8,000 feet that many folks forsake their gardens altogether. Gardeners in the valleys of the Gunnison, Dolores, and Colorado Rivers enjoy especially long growing seasons, with the area around Grand Junction having up to 221 frost-free days in some years. Whereas summers are wet in the eastern areas of the state, they are pretty dry in western areas.

Colorado Climate Profile

Site and elevation (feet)	Average length of growing season (days)	Range of season length (days)	Average date of last 32.5°F temperature	Average date of first 32.5°F temperature
Boulder (5,344)	153	90–197	5/03	10/07
Castle Rock (6,210)	125	55–172	5/22	9/23
Colorado Springs (6,008)	152	110–191	5/07	10/06
Durango (6,523)	110	70–178	6/02	9/19
Estes Park (7,522)	94	17–128	6/03	9/09
Fort Collins (5,003)	142	89–182	5/08	9/29
Glenwood Springs (5,762)	130	85–165	5/19	9/26
Greeley (4,664)	138	94–164	5/11	10/01
Gunnison (7,703)	62	7–98	6/26	8/30
Steamboat Springs (6,728)	47	7–99	7/02	8/23

(Source: Western Regional Climate Center, wrcc.dri.edu.)

Productive Colorado soils, like those throughout the lower elevations of our region, have low acidity, which can cause some nutrient deficiencies. Front Range soils tend to be heavy clays that need amendment. Adding coarse sand equal to about 50–80 percent of the top 8 or so inches of garden soil will go far to amend what you have.

The alluvial soils along river valleys are most productive, as are soils in the moister northeastern parts of the state. Drier soils on the plains of southern Colorado and on the mountain slopes and plateaus are thin and relatively unproductive.

Idaho

Idaho land rises from north to south, with the lowest elevation at the confluence of the Clearwater and Snake Rivers (738 feet) and the highest at Mount Borah in Custer County (12,655 feet). Large parts of the state, especially northern areas, are strongly influenced by maritime air, though eastern Idaho has more of a continental climate. Temperatures are highest at lower elevations of the Clearwater and Little Salmon River basins and along parts of the Snake River valley from Bliss to Lewiston. Gardeners in Swan Falls enjoy the highest annual mean temperature for the state (55°F) while those in Obsidian, at 6,780 feet, experience the lowest (35.4°F). Daily temperature fluctuations are most extreme in the high valleys and the semiarid plains of the Snake River. In fact, the daily temperature from July to September can vary by more than 30°F at Boise.

Idaho precipitation patterns are complex. Average valley

precipitation is greater in southern sections, with large areas of the Clearwater, Payette, and Boise River basins getting 40–50 inches or more per year. On the other hand, large areas in the northeastern valleys, much of the Upper Snake River plains, central plains, and the lower elevations of southwestern valleys receive less than 10 inches per year. In the northeastern valleys and the eastern highlands less than half the rain falls between April and September, while in the Boise, Payette, and Weiser River drainages, less than a third falls in those same months. Low relative humidity throughout the state means dry air and rapid drying of soils and plants.

Idaho Climate Profile

Site and elevation (feet)	Average length of growing season (days)	Range in season length (days)	Average date of last 32.5°F temperature	Average date of first 32.5°F temperature
Council (3,150)	132	104–171	5/25	9/24
Coeur d'Alene (2,160)	141	86–209	5/12	9/30
Kilgore (6,160)	36	7–81	7/10	8/21
May (5,070)	77	53–137	6/17	9/07
Moscow (2,630)	134	61–201	5/18	9/24
Powell (3,630)	86	47–129	6/11	9/08
Salmon (3,950)	93	15–143	6/05	9/12
Twin Falls (3,730)	147	107–191	5/06	10/02
Wallace (2,770)	110	57–161	5/28	9/19
Warren (5,910)	11	1–59	7/25	8/02

(Source: Western Regional Climate Center, wrcc.dri.edu.)

Wind throughout the state can be highly destructive, and good Idaho gardeners plant in sheltered areas or find ways to protect their crops.

As in other states the growing season varies greatly depending on elevation, soil type, topography, and vegetation cover. Lewiston and immediately surrounding areas have the longest seasons in the state. The central Snake and lower Payette, Boise, and Weiser River

basins enjoy about 150-day seasons, while upstream areas of the Snake near Pocatello and Idaho Falls have about 125-day growing seasons. Some high valleys have no growing season at all.

The most productive Idaho soils are the desert soils along the Snake River and the Prairie soils in the western part of the state around Lewiston and Moscow. In general the rest of the state has relatively poor soil.

Montana

Montana has very large climatic variations. The western part of the state is mountainous, while the eastern two-thirds is part of the Great Plains. Elevations vary from a low of 1,800 feet in the northwestern part of the state, where the Kootenai River enters Idaho, to 12,850 feet at Granite Peak near Yellowstone Park. About half the state lies above 4,000 feet. Lands west of the Continental Divide enjoy a modified North Pacific coast climate, with milder winters, more even distribution of annual precipitation, cooler summers, stronger winds, more cloudiness, higher relative humidity, and shorter growing seasons than those of eastern Montana. In western Montana hot spells are rare in summer and of relatively short duration, though temperatures can sometimes top 100°F in the low valleys. Above 4,000 feet it is almost never very hot. Eastern Montana has a more extreme climate with average July temperatures of 74°F in southern areas.

Midsummer days are warm, but nights cool into the 50s and 60s °F. Miles City is one of the warmest parts of the state, having a July minimum of 60°F and an average maximum temperature of 90°F.

Precipitation is highly variable. The western mountains are the wettest area, and nearly half of the annual precipitation falls from May to July. Heron is the wettest location, receiving 34.7 inches of rain on average each year. North-central Montana is the driest part of the state, although the absolute driest spot is near Belfry along the Clark Fork of the Yellowstone River in Carbon County. Belfry receives a mean annual precipitation of only 6.59 inches.

Summer storms are frequent, with hailstorms in July and August causing about $5 million of crop damage annually. June 30, 2010, brought one of the most severe hailstorms the Gallatin Valley had ever seen, with part of the valley receiving softball-sized hail, part receiving golfball-sized, and the rest pea-sized. Roofers, glaziers, and auto-repair shops in the area were kept busy for several years.

Montana Climate Profile

Site and elevation (feet)	Average length of growing season (days)	Range of season length (days)	Average date of last 32.5°F temperature	Average date of first 32.5°F temperature
Billings (3,567)	151	111–180	5/15	9/22
Bozeman (4,900)	112	61–155	5/29	9/14
Great Falls (3,363)	141	107–169	5/11	9/24
Hamilton (3,575)	119	69–173	5/23	9/21
Helena (3,828)	128	83–165	5/15	9/20
Kalispell (2,965)	123	80–150	5/23	9/18
Lewistown (4,940)	117	100–146	5/27	9/15
Miles City (2,629)	147	102–195	5/07	9/27
Missoula (3,197)	115	69–161	5/26	9/20
Plentywood (2,040)	119	108–138	5/19	9/16

(Source: Western Regional Climate Center, wrcc.dri.edu.)

The average growing season for Montana is about 130 days. Most of the agricultural areas enjoy a growing season of more than 120 days, while the middle Yellowstone River Valley in the area around Miles City can expect a 150-day season. The higher valleys of western Montana have no growing season at all.

Soils in the eastern parts of the state are rich and can be quite productive, as can the alluvial soils along major rivers like the Yellowstone, the Milk, and the Missouri.

New Mexico

New Mexico boasts a diverse and attractive combination of landforms, conditions, and plants. Large parts of the state are desert, but much of the state is hilly or mountainous, rising gradually from the east/southeast to the north. New Mexico is more a mountain state than most realize, with more than one hundred named mountain groups. When ranked by highest mountain peak, it's the fifth highest state in the country; the highest point, Wheeler Peak (13,161 feet) tops the highest mountains of both Idaho and Montana. New Mexico is also the fifth largest state, encompassing some 121,589 square miles. Average state elevation is 4,700 feet, with the lowest location in the state being Red Bluff Lake (2,817 feet), where the Pecos River, originating in the Sangre de Cristo Mountains, flows into Texas.

There are three major growing zones in New Mexico, based on the average number of frost-free days: the north, central, and south. Along with these, there are several mountain ranges in New Mexico, each with their associated ecosystems and gardening issues. While

this book may be partially applicable to many mountainous communities, it specifically addresses the Rocky Mountain region including the Sangre de Cristo Mountains, the Jemez Mountains, the Sierra Nacimiento, and the Tusas Mountains. This region has climate characteristics common to the rest of the Rocky Mountains, experiencing the state's coldest and wettest environments. Average annual temperature in this Rocky Mountain region is less than 40°F, while average July temperatures in the higher elevations are in the upper 70s. Average daytime January temperatures are in the mid-30s. Frost-free seasons in this region are typically less than 80 days, and some high mountain valleys can have freezes any month of the year. Relative humidity averages are higher in the mountains owing to lower air temperatures.

Average annual precipitation in the higher elevations is more than 20 inches; in fact, the region is the source of almost all of New Mexico's major rivers. Summer rains can include intense thunderstorms, which may be accompanied by hail. The area east of Los Alamos has the greatest frequency of these hailstorms. Thunderstorms are frequently preceded by strong winds. Sixty percent of the annual moisture falls between May and October, falling as snow in the upper elevations. Precipitation at northern mountain weather stations averages well over 100 inches and undoubtedly exceeds 300 inches in the highest mountains.

New Mexico Climate Profile

Site and elevation (feet)	Average length of growing season (days)	Range in season length (days)	Average date of last 32.5°F temperature	Average date of first 32.5°F temperature
Albuquerque (5,311)	190	152–204	5/25	9/26
Chama (7,850)	87	2–128	6/24	9/14
Eagle Nest (8,203)	70	6–95	5/14	8/26
Espanola (5,595)	148	117–175	5/11	10/08
Los Alamos (7,410)	156	114–186	5/11	10/08
Santa Fe (7,200)	159	113–209	5/10	10/13
Red River (8,750)	69	3–122	6/23	8/30
Taos (6,965)	130	90–162	5/21	9/28

(Sources: Western Regional Climate Center, wrcc.dri.edu; National Weather Service Southern Region Headquarters, www.srh.noaa.gov.)

New Mexico boasts an official state soil! It's the productive rangeland Penistaja series, which covers more than a million acres. Soil pH is usually between 6.5 and 8.4 throughout the state, with mountain soils typically having a lower pH.

Gardeners in the southern Rocky Mountains have been neglected in many Rocky Mountain gardening books. Let's fix that.

Utah

Most of Utah is mountainous, varying from an elevation of about 2,500 feet in the Virgin River Valley in southwestern Utah to 13,498 feet at Kings Peak in the Uinta Mountains. Most of the state receives only light precipitation throughout the year.

Utah Climate Profile

Site and elevation (feet)	Average length of growing season (days)	Range in season length	Average date of last 32.5°F temperature	Average date of first 32.5°F temperature
Alton (6,875)	110	64–151	6/07	9/24
Beaver (5,898)	105	48–154	6/06	9/17
Brigham City (4,320)	160	111–206	5/01	10/13
Cedar City (5,834)	130	75–173	5/26	9/25
Gunnison (5,120)	109	49–154	6/06	9/17
Logan (4,535)	160	80–203	5/06	10/16
Moab (4,025)	182	143–239	4/17	10/18
Ogden (4,350)	164	116–271	5/03	10/14
Orem (4,510)	181	140–234	4/21	10/17
Provo (4,490)	150	118–188	4/22	10/14
Salt Lake City (4,260)	204	175–233	4/13	10/31
Vernal (5,260)	117	69–155	5/25	9/21

(Source: Western Regional Climate Center, wrcc.dri.edu.)

The lower elevations generally are warmer than elevated valleys and mountains. In general, southern counties are 6–8°F warmer than northern counties. There are wide daily fluctuations in temperatures, and on clear nights the cold air settles in the valley bottoms while the benches and foothills remain warm. Experienced gardeners know that the best growing areas are the higher lands at the valley edges. Although there is no orderly or extensive zone of equal length growing season, most agricultural areas of the state enjoy 130- to 150-day seasons.

Precipitation is highly variable, from less than 5 inches per year over the Great Salt Lake Desert to more than 40 inches in some areas of the Wasatch Mountains. The annual average for agricultural areas is about 10–15 inches. Areas of the state below

4,000 feet receive less than 10 inches. Northwestern and eastern Utah are also quite dry.

The chestnut loam soils in the narrow belt at the base of the Wasatch Range are highly productive, as are the dry soils and the gray desert soils in much of western and some parts of eastern Utah.

Wyoming

Wyoming's land rises from north to south, with an average elevation of 6,700 feet. The lowest elevation is 3,125 feet near the northeastern corner of the state; the highest is 13,785 foot Gannet Peak in the west-central part of the state. Eastern Wyoming has an average elevation of 4,500 feet, while the foothills to the west rise to 6,000 feet and more.

The entire state is relatively cool, and areas above 6,000 feet rarely experience temperatures of 100°F. The average maximum temperature in July is 85–95°F, though areas above 9,000 feet have an average July maximum of only about 70°F. The lower part of the Big Horn basin, the lower elevations of central Wyoming, and the northeastern and eastern sections along the border are the warmest. Summer nights are cool.

Late spring and early fall frosts are common. The average growing season in the main agricultural areas is about 125 days. Areas along the eastern border west to the foothills can experience growing seasons from 100 to 130 days, while Farson, near Sandy Creek off the Green River, has only a 42-day season. There is practically no growing season for tender plants in the upper Green River Valley, Star Valley, and the Jackson Hole area.

Elevations greater than 7,000 feet receive annual precipitation of up to 30 inches, with about a third of that falling during the growing season. Southwestern Wyoming at elevations of 6,500–8,500 feet receives 7–10 inches. Lower elevations at 4,000–5,500 feet in the northeastern parts of the state and along the eastern border can expect about 12–16 inches per year. The southwestern sections are very dry. The lower part of the Big Horn Basin, with 5–8 inches, is the driest. Seaver, at 4,105 feet, receives 51/2 inches. Worland, near the southern part of the basin, receives 7–8 inches; Thermopolis, 11–12 inches; and Laramie, in the southeast corner of the state at 7,236 feet, about 10 inches. As an example of how quickly things change in the west, Centennial, only 30 miles west of Laramie, but at an elevation of 8,074 feet, receives about 16 inches per year. The High Plains area receives about 10–15 inches per year, with 9–12 inches of that falling during the growing season.

Site and elevation (feet)	Average length of growing season (days)	Range in season length (days)	Average date of last 32.5°F temperature	Average date of first 32.5°F temperature
Casper (5,112)	122	77–165	5/19	9/16
Cody (5,020)	126	53–178	5/16	9/20
Cheyenne (6,250)	119	93–149	5/15	9/26
Evanston (6,860)	62	17–116	6/26	8/31
Green River (6,080)	100	46–150	6/01	9/12
Lander (5,560)	127	91–171	5/17	9/22
Newcastle (4,380)	133	89–181	5/14	9/24
Powell (4,390)	132	91–179	5/14	9/23
Rawlins (6,850)	129	56–145	6/07	9/20
Rock Springs (6,270)	111	75–155	5/26	9/14
Thermopolis (4,350)	129	66–179	5/13	9/25
Worland (4,060)	133	91–179	5/11	9/21

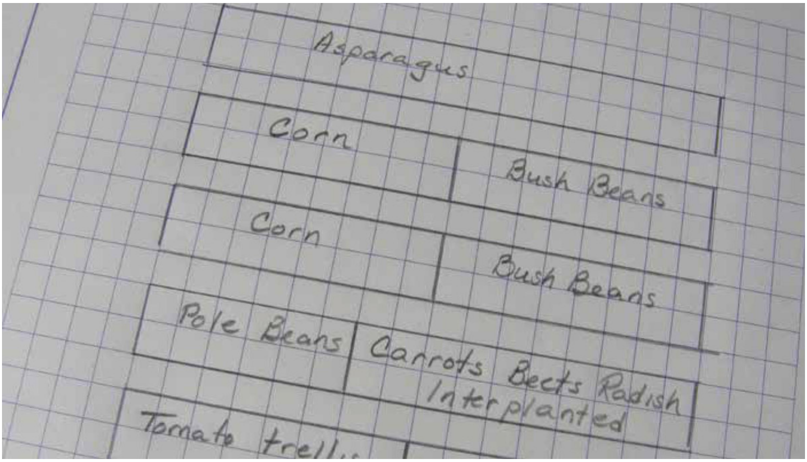
(Source: Western Regional Climate Center, wrcc.dri.edu.)

Gardeners along the eastern border below 4,500 feet can expect a growing season of 130–150 days. The area from the eastern border to the foothills at elevations of 4,500–6,000 feet usually has growing seasons of 100–130 days, while elevations of 6,000–7,000 feet can experience seasons ranging from 80 to 100 days. Shorter seasons of about 80 days or less prevail above 7,000 feet. In some areas frost can occur every night of the year. Both hail and wind can cause problems.

The lowlands of eastern Wyoming have some very fertile moist and dry soils, but low precipitation and low temperatures limit their usefulness. If you can modify these with judicious irrigation and season extenders, as discussed in chapter 11, you will have a great garden.

To Sum it Up . . .

Gardening becomes increasingly challenging the higher the elevation, and the cool summer nights, short growing seasons, and poor soils make gardening at elevations above 7,000–8,000 feet *very* difficult—if not impossible. Site characteristics vary so widely that you must understand your specific garden conditions based upon the soils, precipitation, and climatic conditions within a few hundred yards of your garden. Pay close attention to your location and choose your varieties wisely. And remember, following good neighborly advice will go a long way toward making you a successful gardener.



Chapter 2

Planning Your Garden

A big part of having a successful garden depends on careful planning, so think ahead! Catalogs are usually available midwinter, when there are few yard chores to accomplish and the thought of sunny days in the garden is appealing. Spring is a hectic time, so plan your garden well before the season arrives. Begin by scanning those catalogs when they show up to see what you might like to plant. Then ask yourself a few questions, and be brutally honest about the time you have to invest in vegetable gardening, how much financial investment you want to make, and your interests. Remember, you will become a better gardener in time, and it's tempting to bite off more than you can chew in the beginning!

How Big Is Big Enough?

How big of a garden is enough for you? If you're new to gardening, or even if you're not, there is no shame in starting on a scale that's manageable to fit within your life. First, plant only what you like! If you plan to can, freeze, or dehydrate your vegetables, then plant

more. A quarter-acre garden (10,000 square feet) will feed a family of five for a year. If you include corn, potatoes, cucurbits (vine crops such as squash, melons, and cucumbers), or other space hogs, then you'll need additional space. If your time is limited, then perhaps a garden of 2,500 square feet or even 625 square feet (25 x 25 feet) is a better fit. Some beginners consider a 10 x 10-foot garden a good size. Perhaps the most common vegetable-garden size is 25 x 25 feet. Building raised beds can also save space, and they are indispensable in areas with poor soil. But with a smaller garden, plant only those vegetables that are the most space-efficient, such as beans, root crops, brassicas (broccoli, cabbage, and their relatives), onions and garlic, and the leafy crops such as Swiss chard, lettuce, and spinach. Use space-saving techniques, including trellising cucurbits, allowing them to sprawl onto the lawn, or planting bush types. Growing pole beans instead of bush types will also save space in the garden. Once you identify the vegetables you think you want to grow, check the approximate yields that are included in the profiles of individual vegetables later in the book.

Location, Location, Location

Where you plant your garden can be more important than *what* you plant in it. Choose the wrong site and it won't matter what you plant. Select a spot that receives full sun for at least 8 hours each day. If this is not possible, then pick a site that gets the most sun and plant leafy crops, as they require less sunlight than those that bear fruit.

Vegetable Plants Tolerant of Light Shade

Beets	Green onions	Lettuce	Spinach
Cabbage	Kale	Mustard	Swiss chard
Carrots	Leeks	Radish	Turnip

While some vegetable plants will produce in the light shade cast by buildings, fences, trellises, and tall garden plants, the site should be well away from trees and easy to water. A tree's roots can extend at least one-and-a-half times the spread of its branches, and believe me, you don't want to lug a hose any farther than necessary. Another consideration is exposure; southern exposure is the warmest and produces the earliest crops. However, its soil will dry

faster than soil on other aspects. Warm-season vegetables ripen earlier when planted near the south side of a building or fence. Northern exposures are moister but too cold for a good garden, so never plant within 10 feet of the north side of a one-story building. Move the garden even farther away from taller buildings. Western exposures are nearly as warm as southern exposures, but plants there may be exposed to strong prevailing winds.

Elevation

Elevation is of primary importance in the selection of vegetable varieties for your garden. It is nearly impossible for a 110-day corn to ripen fully in a 110-day season, so at higher elevations plant the varieties that require fewer days to mature. In general, cool-season crops perform best at higher elevations since they generally require shorter growing seasons and fewer days until harvest. Almost all cool-season vegetables are grown for their vegetative parts (leaves, roots, stems, petioles, and immature buds). Cool-season vegetables have smaller root systems and tops than warm-season ones and are frost-hardy, and their seeds germinate at cooler soil temperatures. Their shallow root systems respond to lower levels of nitrogen and phosphorus. Some are biennials, such as cabbage, that are prone to premature seedstalk formation ("bolting") upon exposure to prolonged cool weather. Bolting renders an otherwise edible portion of a vegetable unpalatable. Warm-season vegetables such as tomatoes, peppers, and squash tend to be large plants with large root systems and require a longer season and higher temperatures to mature. They are generally grown for their fruit. There are a few exceptions like peas, a cool-season vegetable grown for its seeds.

If you garden below 5,000 feet elevation, you can easily grow all of the cool-season and many of the warm-season vegetables that require fewer days to harvest. For example, I garden just below 5,000 feet and can easily harvest transplanted tomatoes that have less than a 68-day season and corn with less than a 70-day season. At about 6,000 feet gardeners have to be a bit more selective since you can expect a frost nearly every Memorial Day. Plant only those warm-season vegetables that need very few days to harvest, such as cherry and grape tomatoes and tomatoes of Siberian origins; all will have seasons fewer than 65 days. It will be tough to grow cucurbits and eggplant at this elevation, but you might be able to do it by

modifying your garden's microclimate. Above 7,000 feet choose only varieties with absolutely the fewest numbers of days to harvest and strongly consider season extenders to create warmer microclimates. One season-extending option is to plant against a south-facing wall with protection from wind. Root vegetables, peas, onions, garlic, shallots, potatoes, leafy vegetables, and the brassicas should perform nicely for you. You will have a tougher time with eggplant, peppers, corn, tomatoes, and cucurbits. In all cases, and especially at higher elevations, encourage rapid growth with a good fertilizer that is high in phosphorus, a nutrient that encourages strong growth in cool soils. Go easy on the nitrogen, which delays maturity and ripening of fruit. See chapter 11 on season extenders for more helpful hints to growing at higher elevations.

Kill or remove grass from your future garden site.

A gentle slope of not more than 1 percent (1-inch drop every 8 feet) provides good air circulation and allows cold air to flow down and away from the garden. If the slope faces south, the soil will warm faster in spring, allowing earlier planting. Buildings and trees located at the bottom of a slope impede airflow and contribute to the formation of a frost pocket. Gardens sited in low areas and affected by frost pockets are more subject to frost damage and their

soils may be cold, wet, and poorly drained.

If you are considering planting next spring in an area that is now lawn, kill the grass before you till it under. You can spray the future garden area with a non-residual broad-spectrum herbicide such as glyphosate, use a sod-cutter, and pull up the sod for the compost bin, or cover the area with black plastic and weight it down. Leave the plastic in place for the entire growing season to kill the grass. At the end of summer, turn under the dead grass to add valuable organic matter to your soil.

Space Savers

Some of us just don't have the space to plant a large garden, but you can make the most of what you have by using some space-saving techniques.

Raised Beds

Raised beds are usually about 6–9 inches deep with soil held in place by rocks, bent metal, 2 x 8-inch lumber, or another frame. If you're gardening in thin, infertile soil, raised beds may be just the ticket for you. The best soil for vegetable gardening is a sandy or silt loam. These combine good water-holding capacity with good drainage and are light enough to allow good root penetration. Fill your raised beds with the best soil you can find, and then improve annually with liberal additions of organic matter that can be brought to a fine tilth by thorough preparation. Soil in raised beds warms up earlier in spring than soil in a conventional garden, especially if the bed is sloped about 1–5 percent to the south. I have had both conventional vegetable gardens and raised beds, and I have to say for my use in my garden, raised beds are simply The Best. You'll learn more about raised beds in a later chapter.

Raised beds don't have to be rectangular.

Trellises

Cucurbits and indeterminate (vining) tomatoes like to sprawl, but you can train them to run up a trellis to save space. This "vertical cropping" saves lots of space. A trellis can be built with a wooden frame and poultry fencing and set on posts at a 45-degree angle. Cucurbits will climb up a trellis, but you will have to tie tomato stems in place. Use soft twine, zippy ties, or plastic clips made especially to train tomatoes. A trellis made of heavy twine or wire strung between sturdy wooden posts is an excellent way to train tall peas, pole beans, cucumbers, and tomatoes. The vertical orientation may be a little too much for the vine crops that bear heavier fruit, such as winter squash and pumpkins, so some gardeners make good use of old brassieres, nylon stockings, and onion bags by supporting the fruit in them and tying them to the trellis to take the weight off the fruit stem. It looks odd, but it works.

Use a trellis for indeterminate tomato varieties.

Broadcast Sowing

Most of us plant vegetables in rows, but the walkways between the rows take a lot of space. To save space, consider broadcasting seeds in one row up to 4 feet wide. It will be tougher to weed, but you will be able to harvest an abundance of quick-growing crops such as spinach, Swiss chard, leaf lettuce, and radish.

Putting Your Plan on Paper

You don't have to be a Picasso, but draw your garden plan on paper before the planting season. Include the varieties, crop succession (a new vegetable to follow the one in place), the amount of space you plan to allow for each vegetable, row length and spacing, and the planting dates. Group perennial vegetables, such as rhubarb, horseradish, and asparagus, on one side of the garden so they will be out of the way of the tiller. Plant vegetables that need more growing days, such as tomato, melon, and winter squash, on another side of the garden, and short-season crops, such as carrot, radish, and leaf lettuce, on yet another side. Try to group plants that have similar cultural requirements and that are susceptible to the same pests. For example, group the brassicas (cabbage, broccoli, and their kin) together, the root vegetables together, and the cucurbits together. Plant tall plants like corn on the north side of the garden so they won't shade the rest of the garden.

Flowers in the garden not only look nice but also attract pollinators. My vegetable garden is never without sunflowers, and other flowers such as aster, cosmos, purple coneflower, spiderwort, and lupine all provide pollen and nectar for bees. Tuck these pollinator attractors in wherever you'd like a splash of color.

Example of a Garden Plan

<table>
<tr><td colspan="3">North →</td></tr>
<tr><td>(Border strip)</td><td rowspan="18">Walking aisle</td><td>(Border strip)</td></tr>
<tr><td>Asparagus</td><td>Rhubarb and horseradish</td></tr>
<tr><td>Spinach (spinach late)</td><td>Onions and garlic</td></tr>
<tr><td>Lettuce followed by Swiss chard</td><td>New Zealand spinach</td></tr>
<tr><td>Lettuce followed by Swiss chard</td><td>Peas</td></tr>
<tr><td>Swiss chard</td><td>Peas</td></tr>
<tr><td>Snap beans (bush)</td><td>Peas</td></tr>
<tr><td>Snap beans (bush)</td><td>Peas</td></tr>
<tr><td>Snap beans (bush)</td><td>Snap beans (pole)</td></tr>
<tr><td>Snap beans (bush)</td><td>Snap beans (pole)</td></tr>
<tr><td>Broccoli</td><td>Sweet corn</td></tr>
<tr><td>Cabbage and cauliflower</td><td>Sweet corn</td></tr>
<tr><td>Turnips and rutabagas</td><td>Sweet corn</td></tr>
<tr><td>Carrots and radish intercropped</td><td>Sweet corn</td></tr>
<tr><td>Parsnips and radish intercropped</td><td>Tomatoes</td></tr>
<tr><td>Summer squash</td><td>Tomatoes</td></tr>
<tr><td>Cucumbers</td><td>Winter squash</td></tr>
<tr><td>Cucumbers</td><td>Winter squash</td></tr>
<tr><td colspan="3">(Border strip)</td></tr>
</table>

Special Considerations

Cool-Season Vegetables

Crops that mature quickly

Leaf lettuce, spinach, mustard, radish, turnip, kohlrabi, peas

Vegetables that do poorly in high temperatures; transplant for early ripening or plant for fall harvest

Butterhead lettuce, cabbage, cauliflower, broccoli, Brussels sprouts, celery, celeriac

Vegetables requiring a long season

Beet, carrot, parsnip, salsify, horseradish, chard, kale, endive, onion, leek, garlic, shallot, potato

Warm-Season Vegetables

Vegetables with shorter seasons that can be directly sown to the garden at lower elevations

Bean, sweet corn, cucumber, squash

Vegetables with long seasons that should be transplanted to the garden

Tomato, eggplant, muskmelon, pepper, watermelon

It’s a relatively minor consideration, but try to plant in rows running north to south to allow the best distribution of sunlight. Plant corn in small blocks of several rows each, rather than in a few long rows, to permit better pollination and greater yields. If you *must* plant corn in a single row because of space constraints, place 3 kernels in each planting hole to increase the number of plants in your stand . . . and cross your fingers.

Sow fast-maturing, short-season vegetables such as leaf lettuce and radishes in short rows at 2-week intervals. This allows an extended harvest season so that you don’t end up with 10 bushels of radishes in a single harvest! Consider intercropping, which is planting fast-maturing vegetables such as radishes and leaf lettuce between rows of long-season ones such as carrots, tomatoes, and peppers. The radishes utilize the empty space when the tomatoes are small and come up long before the carrots show their tops. By the time the tomato plants need more space, the radishes will have been harvested. Likewise, within the carrot row, pulling the radishes will help thin the carrots and loosen the soil around them. Be advised, if you have a heavy, clay soil, harvesting the radishes just might bring up all the carrot seedlings, too.

If you remember to plan before you plant, you’ll be on your way to a rewarding experience! And like everything else in this world, the best-laid plans sometimes just don’t end up the way you

thought. That’s okay. There’ll be another garden next year!

Chapter 3

Different Strokes for Different Folks: Cropping Methods

If you want to get the absolute most from your garden, there are several fun and interesting methods you can try, such as intercropping and companion planting. If your season is long enough, you can succession plant another vegetable or a soil-building cover crop to till in before winter hits and to keep the weeds down. Even if you have a small garden, rotating your vegetables avoids diseases and nutrient depletion, and confuses insects that prefer certain crops. The use of these gardening methods can separate good gardeners from excellent gardeners.

Companion planting is a term that encompasses so many concepts as to be nearly meaningless unless defined. Some concepts are scientifically proven; others run the gamut of pseudoscience from metaphysical to just plain silly. In the latter category are concepts that anthropomorphize plants; that is, they give human traits to plants and confuse human and plant morality. For example, saying that plants A and B should be planted together because A “loves” B has no basis in reality. Judging which plants should be planted together based upon their “vibrations” and “rhythm” is unscientific, but it’s attractive to those with metaphysical leanings. Using the idea of sensitive crystallization, wherein extracts of plants A and B are mixed and allowed to evaporate, and the patterns of their residual crystals studied to see if the plants are compatible, is based in metaphysics. The various tables found in the literature that give companion plant associations are based on a combination of observation, anecdotal evidence, science, pseudoscience, and folklore, and their validity is difficult to establish.

Plant radishes near tomatoes as a trap crop for flea beetles to avoid this scene!

That being said, some aspects of companion planting are scientifically valid and should be observed by all good gardeners.

Trap cropping uses one crop to attract insects away from another. For example, radishes planted near carrots attract wireworms and root maggots away from the carrots. Kale attracts harlequin cabbage bugs away from cabbage, and intercropped patty pan squash attracts pickleworms away from cucumbers. Beans attract armyworms away from tomatoes; collards attract the diamondback moth away from cabbage. Needless to say that the trap crop, having done its job, will be pretty much useless. Perhaps we should call it a "sacrifice crop"?

Some plants release a compound from their roots that may suppress or enhance the growth of nearby plants. Black walnut releases juglone, which inhibits the growth of many plants, while African marigold releases a compound called thiopene that repels

nematodes. The African marigold (*Tagetes erecta*) is not the marigold found commonly in flower beds, which is the large-flowered marigold, also referred to as the American marigold. While they may be planted in the garden, the marigolds you purchase at the garden center are often hybrids and are mixes of such species as *T. erecta*, *T. patula*, and *T. tenuifolia*. Not all of these have been shown to have nematocidic properties; researchers refer specifically to *T. erecta* as having those properties. So, you'll have to look specifically for the African marigold or plant seeds of that species for this purpose.

Nurse cropping is the use of one plant sown directly in the row or in very close proximity to another to assist their growth in some way. For example, parsnip and carrot seeds are notoriously slow to germinate. Between the time they are sown and when the seedlings emerge, the soil may crust, preventing many of the weak parsnip and carrot seedlings from emerging. During that time, weeds may also emerge, and it will be difficult to hoe between the rows if you don't know where the rows are. Mix radish seeds with the parsnip and carrot seeds. The radish seeds germinate quickly, break through the soil crust, and mark the rows. In addition to serving as a nurse crop, the radishes will attract some insect pests away from the parsnips, and when you harvest the radishes, you will help thin the rows of parsnips and carrots. If your soil is particularly heavy, be careful when harvesting the radishes, as you just may pull out all of your developing carrots along with your mature radishes!

Intermingling tall, full-sun plants with small, shade-tolerant plants makes good use of space. This is a form of nurse cropping. The "Three Sisters" scheme of planting pole beans to climb corn stalks and planting squash vines between the corn plants has many benefits. The beans use the stalks as "bean poles" to reach greater amounts of sunlight, while bean root nodules that fix nitrogen leak or die, liberating nitrogen for use by the corn. (Living legumes, such as beans and peas, form nodules on their roots that process [fix] nitrogen, making it available to plants. The real value of these nodules is realized after the legume dies, and the roots and nodules are incorporated into the soil and rot.) Squash vines cover the soil and reduce weed growth, and their prickly stems are said to deter raccoons from eating the corn, although I've had raccoons in my corn, and I'm not sure I believe anything would deter a raccoon who senses ripe corn.

Intercropping is planting some plants between rows of others. For example, plant radishes between rows of tomatoes. The radishes will use the space well and will be harvested before the tomatoes need the extra room. The same is true for short-season leaf lettuce planted between rows of longer-season crops like cabbage and tomatoes. Always intercrop whenever possible to get the maximum yields and provide biodiversity in your garden. But with the increase in productivity, you will have to pay close attention to increasing your watering and fertilizing regimes to support the extra growth on what would otherwise be bare ground.

Plant short-season leaf lettuce between rows of cabbage.

Finally, planting many crops in a small space creates greater biodiversity and encourages a healthy population of pollinating and beneficial insects. In addition, mixing plants of different types and varieties ensures that if a pest outbreak should occur on one crop, you will have other crops that are not attacked.

Crop rotation involves not planting the same or similar crops in the same location in successive years. Mix it up! For example, if you plant spinach in the same spot every year, spinach pests will build up in that location. Also, because certain plants make greater use of some nutrients, planting the same crop in the same spot year after year depletes that soil of those nutrients; if your child only eats hummus and tomato sandwiches, you will soon run out of these items while the quinoa salad remains untouched and plentiful. In a similar manner, beets and carrots are heavy users of potassium; planting them in the same spot year after year reduces soil potassium levels but leaves levels of other nutrients like nitrogen and phosphorus relatively high. Corn makes relatively high use of nitrogen but uses phosphorus and potassium in lesser amounts. So planting corn where beets were planted the year before makes good sense. While some gardeners enjoy a nutrient-heavy rotation system such as this, there are many other good systems for rotating your crops. The most important thing to remember is to do it!

Here are some general guidelines for good rotation practices: Do not follow crops with crops in the same family. For example, do not plant cabbage where broccoli was planted the year before since they both belong to the Mustard (Brassicaceae) family . Tomatoes and peppers are in the Nightshade (Solanaceae) family and should not follow each other. If you plant cabbage on the south side of the garden this year, plant it on the north side of the garden next year and on the east side of the garden in the following year.

Plant a root crop where a fruit crop like peppers or tomatoes or a leafy vegetable like lettuce or Swiss chard was planted the year

before. An exception to this is to avoid following Swiss chard or spinach with beets because all three belong to the Goosefoot (Amaranthaceae) family.

Follow heavy feeders with light feeders; follow corn with lettuce. Follow shallow-rooted crops with those that are deep rooted.

If it takes 2 years before you plant the same plant in the same spot again, that is called a 2-year rotation; if 5 years, then a 5-year rotation. Try to practice at least 3-year rotations, although longer rotations are even better. For example, let's take an imaginary spot in the garden. In year 1 we plant it to spinach, which is a shallow-rooted leafy crop in the Goosefoot (Amaranthaceae) family. In year 2 we plant it to carrots, a moderately deep-rooted root crop in the Parsley (Apiaceae) family. In year 3 we plant tomatoes in that spot. Tomatoes are a deep-rooted fruit crop in the Nightshade (Solanaceae) family. In year 4 we return to planting spinach in that spot once more, ending a 3-year rotation scheme. In this scheme we rotated by family, root system, and edible part. If we had the space to take that spot out of production for 1 year, planting it in a cover crop (also called "green manure") instead of returning to spinach, it would be even better, and a 4-year rotation.

Succession planting is following one vegetable crop with another crop in the same season. It requires more watering and fertilizer but will also increase your season's yields. After one vegetable is harvested, till the soil and plant another crop in its place right away, getting two crops where one would normally be grown. However, you must consider how much of the growing

season remains, how many days to harvest your second crop requires, and the climatic conditions under which that second crop will mature. Not all combinations work in all gardens. For example, turnips following onions will probably have sufficient time to mature under the cooling conditions of late summer and early fall. However, eggplants following onions will probably not work for you because eggplants need a long season and warm days to mature. In my garden, I harvest onions about the second of August and can expect a frost by mid-September, and sometimes much earlier. If I'm lucky, I'll have about 1 month left after onion harvest in which to mature another crop in that spot. Transplanted kale works well, as does spinach, as both will produce reasonable plants in a month or so and also will tolerate light frosts, thus extending their seasons for an additional 2 weeks or more. Try following bush beans with leaf lettuce, spinach, or turnips to mature in the fall; spring radishes can be followed with bush beans, then with a fall crop of spinach or turnips.

Here's where that knowledge of warm- and cool-season crops can be put to good use, as succession cropping also refers to planting at intervals throughout the season, such as planting at 2-week intervals during seasons appropriate to the plant, for example Swiss chard for young leaves. Succession planting a quick-growing cover crop, such as barley or rye (see full list of cover crops and planting times on page 101, after removing the shorter-season vegetable crop, and turning in the green vegetation prior to it setting seed, increases the organic matter in the soil in that spot and will decompose by planting time the following spring. Cover crops also play an important part in weed suppression. Aristotle said that nature abhors a vacuum, and if you leave a spot of unplanted ground, it will be filled with weeds. Cover crops compete with those weeds by filling the niche they would occupy.

Relay cropping is a hybrid of sorts between succession cropping and intercropping. For example, you can plant corn seeds or tomato plants beneath the foliage of early cabbage plants. The cabbage leaves will protect the seedlings and transplants from a late frost, and the cabbage head will be harvested before the relay crops need the extra space.

Fallowing is letting a portion of your garden remain uncropped for a season. The soil may be left bare, or, better yet, it may be planted to a cover, or green manure crop. This idea of letting the

land “rest” reaches back at least to Roman times and was part of the standard planting practices through the Middle Ages. It allows the soil to soak up moisture when not planted and, if planted with green manure, allows the organic matter turned under before setting seed to fully decompose before the following season. It also removes the land from production for a season and is therefore not practiced where space is limited.

Preparing the Land

Preparing the land for planting is very important. Most gardeners simply use a rototiller or spade in their conventional garden, turning under organic material and soil amendments, as well as loosening the soil to a maximum depth of about 8 inches for good root penetration and plant growth. However, repeatedly spading or tilling to the same depth every season can result in formation of a hardpan, which restricts penetration of water and roots to greater depths, reducing the amount of underlying nutrients available to plants. In the case of root crops such as carrots and parsnips, a shallow hardpan means roots may be stumpy and/or forked. Try to till to different depths each year and, if a hardpan is present, break it up with a pickax or a subsoil or chisel plow, if your garden is large enough to get the equipment in.

Rototilling prepares and fluffs the soil and does a good job of mixing and incorporating fertilizers and organic materials. However, there is some concern that it tends to over-aerate the soil, hasten organic matter decomposition, and force the gardener to keep a sharp eye on adding amendments. Many gardeners use rototillers for cultivating between rows. This is a poor practice as the tiller will dig too deeply, destroying many of the vegetable crops' surface feeder roots. Cultivate by loosening the soil surface with a hand cultivator or hoe, not by tilling it.

Double-digging is a labor-intensive process designed to loosen the subsoil, and it's often used to prepare raised beds. Start at one end of the row and turn up a strip a foot or so wide across the garden. Remove only the topsoil and put it out of the way. Now, dig and break up the subsoil at the bottom of the trench but leave it in place. Work rotted manure or compost into the subsoil. Lastly, spade the next strip and put the topsoil from it onto the amended subsoil in the previous trench. Continue on in this fashion until you reach the end, and use the first topsoil you set aside to fill in the last trench.

Raised beds are quite useful in Rocky Mountain gardens, but they do require more time and energy to construct and maintain than a conventional garden. However, they can be filled with good topsoil and compost to replace the existing poor, wet, or very dry soil. They allow for cultivating and harvesting from at least a foot off the ground, making the chores easier for elderly and physically challenged gardeners. Since gardeners don't walk in them, their soil is less compacted and easier to dig, and it warms faster in spring, allowing for somewhat earlier planting. Surrounding your raised beds with foot-friendly mulch allows for easier access after watering. Lastly, raised beds have a tidy look about them that makes them fit nicely into suburban and urban landscapes. But there are some downsides to raised beds. You cannot easily use a full-size rototiller on the smaller beds, and they usually require more frequent watering than an in-ground garden.

Raised beds can be constructed with any number of materials. Completely dried railroad ties are an easy border, as are landscape timbers. Permaculturists prefer rocks, and bent metal may be used for those who prefer nonconventional bed shapes. Cement blocks

are another means to build the bed, but they are not very attractive. Perhaps the most commonly used material for constructing the walls of raised beds is 2 x 8-inch or 2 x 10-inch dimension lumber, the boards screwed into posts at the four corners to make a square or rectangular bed. Be sure not to get carried away with the bed dimensions, as you should be able to reach the center of the bed from outside. Therefore, make the beds no wider than about 4 feet, or twice your length of reach. If you have a problem with moles or burrowing rodents, fasten a layer of 1/2-inch-mesh hardware cloth to the bottom of the bed before you fill it.

Less traditional raised beds include stock tanks, and plans are readily available online to help build raised beds on stilts to accommodate wheelchair users. Some catalogs offer raised-bed kits that allow users to stand comfortably.

If the underlying soil is good, it is not necessary to fill the bed to the top of the frame. Use good soil but think twice about purchasing it. A 10 x 4-foot raised bed with 2 x 10-inch sides requires about 30–35 cubic feet of material; that will get pretty pricey purchased by the bag at the local hardware store, but often it may be purchased in bulk at a local nursery. Try building up your own soil year by year and mix in a few purchased amendments. Use compost and some topsoil from your existing garden, some coarse sand, and some fertilizer. Over time your "made" soil will blend and mellow. Keep in mind that the plant material you remove from the beds each year came from the soil! So be sure to add plenty of organic matter to the raised bed each year, but not so much as to hamper plant growth. We'll discuss soil amendments, including compost later, in chapter 8.

Raised beds can also serve as mini-greenhouses by covering them with a "hoop" of 2 x 4-inch-mesh welded wire and fastening polyethylene or spunbonded fabric to it. Leave the ends open since spring temperatures in some areas may rise into the 80s and 90s°F, "cooking" your early crops. You can also arrange the covering so

you can roll it off, over the hoops, to take advantage of good weather.

Unprotected vegetable gardens are at the mercy of Mother Nature's hailstorms.

These wire hoops also provide some protection from hail—another of Mother Nature's challenges in our region. Plant the cucurbits at one end of the bed so they can trail out onto the surrounding area as they grow, saving raised bed space for the other crops.

Good gardeners produce a bountiful harvest for their family and friends. Great gardeners utilize different systems and methods to produce that bountiful harvest, while making full use of their garden space, holding diseases and insects at bay, and providing their plants with all the extra support these systems give. Using rotation, cover cropping, nurse cropping, companion planting, and all the rest will help keep your dynamic garden in balance and highly productive.

Chapter 4

Purchasing Seeds: Starting Your Garden with Nature's Perfect Package

Home gardeners are truly fortunate. A vast world of different and unusual vegetables, and better tasting common ones, is open to you once you begin to grow your own food. You have a choice between growing your vegetables from seed inside or as transplants or direct seeding to the garden. Transplants are often used for warm-season crops that require more frost-free days than local conditions permit, but are just as often used for cool-season plants that stall, bolt, or will not grow at all in the heat of the summer. Transplants are readily available at nearby garden centers for those not able to start their own, but to me, that's part of the fun.

Selecting from the Vast Array of Seeds

Supermarkets, hardware stores, and garden centers typically carry a limited, usually inexpensive selection of widely adapted varieties. But why settle for run-of-the-mill seeds? You have many ways to purchase high-quality seeds that pique your interest. The number of seed companies is legion. Some large companies offer varieties adapted to a wide range of conditions; some offer varieties that do better in the Northeast or Deep South. Some offer only seeds from which you may select the best-performing plant in your location, and save seeds for next year's garden. You, as a Rocky Mountain gardener, need varieties best suited to our special conditions. Choose the right ones and remember that seeds, no matter how expensive, are your least expensive investment.

Seed catalogs and their websites, as well as seed packets, give you lots of information. But don't worry—I'll tell you how to work your way through it.

Seeds from Hybrid and Non-Hybrid Plants

'Sungold' is a popular F_1 hybrid cherry tomato.

Seeds from hybrid plants, most of which are the result of purposeful breeding by humans, have been around for a long time. The first hybrid tomato, 'Mikado', was released by the Rice Seed Company in 1880, and commercial hybrid corn made its debut in 1921. By the end of World War II, almost all farmers planted hybrid corn. Hybridization of other vegetables soon followed. First generation hybrids, called "F_1" for "first filial generation," are usually more vigorous than their parents; produce larger, more uniform crops that may ripen in a shorter season; and may have resistance to multiple diseases. Because their production and development is costly, hybrid seeds usually fetch a slightly higher price than those of standard, open-pollinated varieties, but this is a small price to pay for all of the benefits of hybrids. One downside is that hybrid seeds will not produce plants that grow true-to-type in the next generation. So, if you save seeds from the fruit of the hybrid 'Early Girl' tomato, they *will* produce tomato plants but they *will not* produce 'Early Girl' tomatoes; rather, the tomato plants will revert

to one of the parental types that was used to create the 'Early Girl' variety.

Many gardeners prefer to plant the standard, non-hybrid varieties because they have some unfounded fear of the new hybrids, or they simply like the charm of planting something "old-fashioned." Others may feel strongly about maintaining and preserving genetic diversity, thereby avoiding genetically identical plants, all of which are susceptible to the same pests and diseases (think Irish Potato Famine).

'Detskiy Sladkiy' is a robust heirloom container tomato from Russia. My sister brought seeds back from a trip to Alaska. It was doing quite well on my front porch in late June, and was producing 3-inch fruits by the first week in August.

Heirloom varieties are open-pollinated, old standards. While definitions vary, heirlooms have been around a long time, usually at least 50 years, have documented histories, often have colorful names, and unlike hybrids, reproduce true-to-type. Heirlooms often have less pest resistance and less uniformity than the hybrids, and sometimes are not as "pretty," but they certainly make up for that in character. They will come true-to-type; that is, seeds saved from an open-pollinated variety will produce plants nearly identical to the parents. So you can save their seeds for your next year's crop. While some heirloom varieties certainly perform best in Texas or Maine, you never know until you put them into your own yard which plants will thrive under your conditions. One of the beauties

of planting heirlooms in your garden and saving their seed is that you can select seeds from the plants that grow best *under the growing conditions in your yard*. You can select from the tomatoes that form earliest and are tastiest and most disease resistant *in your yard*. More on saving seeds later!

Variety Characteristics

Seed catalogs you receive in the mail typically only show the tip of the iceberg when it comes to varieties they sell, so be sure to look at their online catalog as well! Whether you're reading a catalog description or a seed packet, read the description of the variety carefully. I tell my Montana State University students not to get taken in by the sexy photo. In our growing conditions, chances are the vegetables we grow won't look quite so gorgeous. Think tomato photos you've seen . . . *BIG* tomato with *little bitty hands*.

Again, read the description carefully. Determinate or "bush" varieties, as found in snap beans and tomatoes, produce plants that are compact and that ripen over a short period of time. These are useful on windy sites and when you want to have your harvest all at once, so you can freeze or preserve in large batches. Indeterminate vining varieties (also called "pole" when it comes to snap beans) produce large, sprawling plants that ripen over a longer period of time. These work better on protected sites and where you don't intend to have a single canning day but wish to eat a little at a time over the season. They also work well for those folks who are space-challenged and need to grow "up"!

Beans can be indeterminate (pole) or determinate (bush) types.

Some varieties of peas and other vegetables are better used for processing, some are better for eating at harvest, and some store better than others. Again, *read* the description! Many varieties have various strains; think of these as “subvarieties” that have certain beneficial characteristics that distinguish them from the parent variety, though these characteristics are not great enough to be considered a new variety. For example, ‘Kentucky Wonder’ rust-resistant strain is a subvariety of ‘Kentucky Wonder’ bean that has resistance to the rust fungus. It is otherwise identical to its parental strain and will produce beans that are indistinguishable from the parent type except for their resistance to the fungus. Selecting certain strains allows us to fine-tune varieties for our conditions.

Some varieties are regionally adapted and some are adapted to larger areas of the country. For example, ‘Vantage Point’, a late-maturing green cabbage, performs well in gardens from Texas to Canada, while ‘Red Express’, a red cabbage, is recommended for northern gardens only. Heirloom varieties have been selected through the generations because of their adaptability to local environments; therefore, they may not be adapted to wide areas of the country. All the more reason to get some heirloom seeds, plant them in your garden, select the best ones for your location, and save their seeds.

While thumbing through catalogs, look for the AAS designation.

The All-America Selections (AAS) program began in 1932. It tests a large number of newly introduced vegetables and flowers throughout the United States and publishes an annual list of those winning varieties that performed the best in the widest number of conditions. Recently they have added regional designations, as well. Check out their website at all-americaselections.org.

Days to Harvest

Most seed packets and catalogs list that vegetable's "days to harvest." *This is important.* If the vegetable seed is usually sown directly to the garden, such as carrot, the number refers to the average number of days from *sowing* to harvest. If the plants are usually transplanted, such as tomato or eggplant, then the number refers to the average number of days from *transplant* to harvest. For example, my favorite determinate heirloom, 'Black Sea Man', is a 75-day tomato, which means it requires, on average, 75 days to mature from transplant to harvest. Days to harvest is not a precise number but an *average* number of days in an *average* year (we know how often that happens) in an *average* soil and in an *average* location. Experienced gardeners use "days to harvest" to compare ripening speed of different varieties.

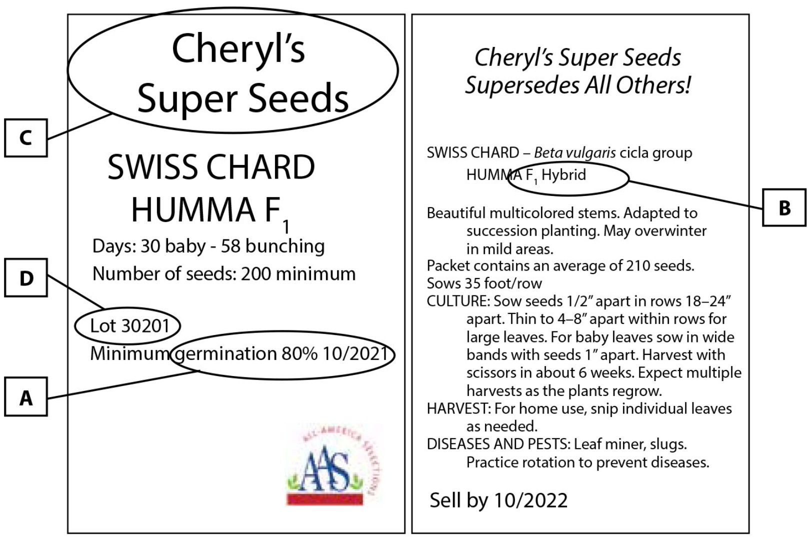
Further, it is not as simple as figuring that a 120-day season should accommodate a 90-day sweet corn. Because our Rocky Mountain weather is cool in the spring, the actual growing season for aboveground crops is almost always shorter than the published one. You may have 120 days between average frost dates, but cool-season crops don't grow much at temperatures below 45°F, and warm-season vegetables need at least 50°F to begin their growth. Factor in our cool nights, which slows growth of warm-season vegetables, and you really have a shorter effective growing season than you think. For example, a 63-day corn requires about 90 days to ripen south of Bozeman, Montana. This consideration is most important with aboveground vegetables that are exposed to frosts. However, root vegetables like carrots and beets are not only hardy but are protected from cold autumn weather by the soil, so there is no trick to growing a 120-day parsnip in a 90-day growing season. If this is a little confusing, just remember that aboveground vegetables are more strongly dependent on the length of the growing season than the soil-protected root vegetables.

Customize Your Tomatoes

'Black Sea Man' is categorized as a 75-day determinate heirloom tomato. It looks funny but tastes delicious. I've been growing and saving seeds from the earliest ripening 'Black Sea Man' now for about 10 years, and even in my short growing season, these delicious tomatoes will ripen in my Bozeman, Montana, garden.

Reading between the Lines: Seed Packets

By law, seed packets must state the percentage of germination of the seeds they contain and the date the germination was tested (A). For example, this packet states, "Minimum germination 80% 10/2021." This ensures that you would be purchasing good, viable seeds for the 2022 season. Germination standards are set by the federal government, and, although they vary among vegetables, most seed packets must state at least 60 percent germination to be legally sold in interstate commerce.



SEED PACKET FRONT SEED PACKET BACK

Packets must also provide certain other information. The kind, variety, and hybrid/non-hybrid designation must appear on the packet (B), along with the name of the seed company (C), the lot number (D), and whether or not the seed has been treated with some sort of pesticide (our sample packet is not treated).

Some seeds are treated with a pesticide to protect them during germination. Fungicide-treated seed often has better “come up,” especially in cold, damp soils where germination is slow and diseases flourish. Treated seed are brightly dyed to distinguish them from non-treated seed. Many gardeners prefer organic methods over seed treatments, choosing instead to wait until the soil warms to avoid seed rots. But to other gardeners, treated seed is highly beneficial in helping to establish a good, early crop. The choice is yours.

Many companies offer both certified organic and nonorganic seeds. Organic seeds are often more expensive than traditionally produced seeds and will not necessarily produce a better crop for you. Whether you prefer to go organic or not, let your personal viewpoint be your guide.

Easier Seeding for Small Seeds

Small seeds may be pelleted (right) for ease of planting.

Some seed companies offer seed tapes and pelleted seed. Both are intended to assist the gardener and professional grower alike with planting and thinning tiny seeds, such as carrot, lettuce, and celery. Seed tapes have the seeds pre-positioned at a space easy to work with and encased within degradable paper. Simply roll out the tape, cover lightly with soil, and water. Pelleted seeds have been covered with inert material that increases the size and standardizes the shape of tiny seeds for ease and precision of planting by hand or by machine.

Resistance and Genetic Codes

Many varieties are resistant, but not immune, to various insects and diseases. Most of these traits are present in hybrids as the result of careful breeding programs, but some resistance occurs naturally. Resistance traits are given in a code following the variety name. For example, a tomato labeled "'Superduper' VFN" is resistant to the fungal diseases Verticillium wilt and Fusarium wilt and to Nematodes. See the vegetable profile on sweet corn for codes that refer to corn's genetic traits for sugar production and retention. Since not all locations harbor all pests, more resistance codes (and a more expensive seed) do not necessarily mean a better variety for you. It's not necessary to pay extra for resistance you don't need. Contact your local county extension office to find out the diseases and pests that are prevalent in your area. But to give you an idea, the following is a (very) short list of tomato resistance codes and what they mean. Most seed catalogs have even more extensive lists, and designations may be slightly different in various catalogs.

Resistant varieties are a boon to gardeners, particularly where vegetables have been grown for a long time and pests and diseases have increased to destructive levels. Gardeners preferring organic methods should plant resistant varieties to avoid chemical controls. Many hybrids carry some resistant traits, though some non-hybrid varieties may also have some resistance to certain diseases and insects as well.

Selected Tomato Resistance Codes and Their Meanings

Resistance Code	Meaning
AB	Early blight
F	Fusarium wilt
LB	Late blight
N	Nematodes
PM	Powdery mildew
TMV	Tobacco mosaic virus
TSWV	Tomato spotted wilt virus
V	Verticillium wilt

National, Regional, and Specialty Catalogs

There are many large seed companies that market to a national audience, carrying varieties that produce good crops from Florida to Washington. There are also smaller companies that market to regional audiences and offer regionally adapted varieties. Finally, there are specialty catalogs that offer only one commodity, such as tomatoes or garlic. These are wonderful sources for unusual varieties, but remember that many of those varieties may not be adapted to our region. Read the variety descriptions in a catalog prior to making your selection.

Snake Oil in the Garden

Beware the advertisers who blur fiction and fact in order to push their product. The variety description should actually tell you something; look for facts. Beware of statements such as “This is the earliest-maturing carrot we have ever seen.” Maybe they’ve seen only one? Rather, look for statements like “This beet ripens on average 10 days earlier than ‘Early Wonder’.” “This miraculous variety was produced by world-famous breeders at a leading university” says nothing. Why not name the breeders and the university? A more factual statement might be, “This very high-yielding, deep orange carrot was developed by Drs. L. Smith and W. Jones at Colorado State University.”

Sometimes very old varieties are advertised as high-priced novelties. Blue potatoes, black corn, black tomatoes, lemon cucumbers, and purple carrots have been around for a long time. They aren’t new, so why pay extra for them? Be skeptical of high-priced fertilizers that provide “30 vital nutrients.” Plants need only seventeen elements for growth, so why pay more to give them what they don’t need? Beware of words such as *magic*, *miraculous*, *amazing*, and *breakthrough*, the use of picture-perfect vegetable photos, and the like. In short, ignore the hype and look for the facts.

Chapter 5

Saving Seeds: Tailoring Vegetables to Your Garden

Through the early 1950s many gardeners still saved seeds from their vegetables year after year. Tomatoes were allowed to rot in order to extract their seeds. Dill was allowed to stay in the garden until (horrors!) the seed heads shattered (folks with old garden plots still have dill come up as welcome weeds).

During the 1950s and 1960s, inexpensive, high-quality hybrid seed became widely available, and folks simply purchased new seeds each year. But in the 1970s forward-thinking gardeners began to realize that we were losing genetic diversity, flavor, and vegetable “character” as the colorful old varieties such as ‘Lazy Housewife’ bean and ‘Bloody Butcher’ tomato were fast disappearing. So began a movement to save seeds from favorite vegetables once more. Today, many gardeners enjoy doing just that. They maintain the old lines and again taste the flavors of a long-ago time. To some folks, there is a certain charm in eating the same

variety of beet that Thomas Jefferson ate. To me, it's the charm in eating the same varieties of plants my late husband and I planted each year, such as 'Black Sea Man' tomato. Saving your own seeds is not difficult, but it does take time and planning. Try it, but you must play by the rules.

Saving seeds from hybrid (F_1) varieties will result in a plant that does not "come true" in the next (F_2) generation. To ensure your harvest will be predictably the same variety, save only from "open-pollinated" varieties. Most older varieties, like 'Champion' radish and 'Bellstar' tomato, are open-pollinated. Plants that are open-pollinated may further be divided into three categories: cross-pollinated, partially cross-pollinated, and self-pollinated.

Cross-pollinated and partially cross-pollinated vegetables are those that are pollinated by other varieties of the same kind of vegetable. Spinach can be cross-pollinated. If you plant 'Winter Bloomsdale' spinach in isolation, then the seed it produces will continue to produce 'Winter Bloomsdale' in following years. But if you plant different varieties of spinach in your garden in the same year, say 'Winter Bloomsdale' and 'Olympia', they will cross-pollinate and the seed you save will produce an off-type the following year. That's fine if you want to experiment, but if you want to maintain varietal purity, you must isolate it from other varieties of the same kind of plant.

Isolation for Genetic Purity. Knowing the method of pollination for the different vegetables can be important when considering isolation. Following is a table of some commonly planted cross-pollinating or partially cross-pollinating vegetables and their means of pollination.

Isolation is often difficult. Commercial growers may separate fields of different varieties by as much as 5 miles, but telling home growers to do this is unreasonable. Either avoid planting multiple varieties of the same vegetable in the same year; plant varieties of the same kind of vegetable with different maturity dates; or, if you have a large garden, separate different varieties by at least 250 yards. Planting tall, thick plants, such as sunflowers, between varieties can also be an effective means of isolation. The simplest plan for a beginning gardener is to pick one variety you think you'll like of any vegetable and plant just that one. Once you know the ropes, you can experiment more. Brassicas, including broccoli, cabbage, and so forth, all intercross, so you will have to isolate

them from each other as well.

Typical Pollination of Selected Vegetables

Insect pollinated

Asparagus	Celery	Onion	Radish
Broccoli	Cucumber	Parsley	Rutabaga
Brussels sprouts	Endive	Parsnip	Turnip
Cabbage	Kale	Pepper	
Carrot	Kohlrabi	Pumpkin/ squash	
Cauliflower	Melon		

Wind pollinated

Beet	Swiss chard	Corn	Spinach

But wait—there's more! Cucurbits (members of the pumpkin and squash family) belonging to the same *species* will cross, resulting in seeds that will produce off-types. It is not simply a matter of separating pumpkins from squash, as there is no botanical difference between the two. Rather, you must know the species to which each variety belongs in order to separate them effectively. Any varieties within the same species will cross-pollinate. For example, 'Jack-o'-Lantern' pumpkin and 'Acorn' squash belong to *Cucurbita pepo* and will cross-pollinate. Varieties belonging to *C. pepo*, *C. moschata*, and *C. argyrosperma* will cross with each other; for example, zucchini will cross with 'Butternut' squash and 'Green Striped Cushaw' pumpkin. Varieties belonging to *C. moschata* and *C. maxima* will also cross with each other; for example, 'Kentucky Field Pumpkin' and 'Big Max' pumpkin. Watermelon (*Citrullus lanatus*) belongs to a genus different from the squashes, pumpkins, and muskmelons and will not cross with any of them. Cucumbers (*Cucumis sativus*) and muskmelons (*Cucumis melo* [Cantaloupensis group], although they share a genus, differ in species and will not cross with each other or with the squashes and pumpkins. The winter squash entry in The Vegetables section (page 283) contains a partial list of varieties within each species for the plant nerd in all of us.

The corn on the right has a much earlier maturity date than the one on the left. It will be done tasseling and silking long before the left-hand variety starts tasseling.

This question is often asked: If squash will cross in the garden, won't that result in weird fruit this season? The answer has to do with genetics. The actual species cross occurs in the *seeds*, so the fleshy part of the winter squash fruit that we actually eat maintains the genetics of the plant that bears it. Theoretically there will be no difference in that flesh. Recall, however, that we do consume the seeds of summer squash, and it's possible that species will cross with another nearby squash, resulting in potential off-flavors in the summer squash.

When I first started down the vegetable-gardening and seed-saving path, it was strongly believed that tomatoes are completely self-pollinating due to the structure of their flowers. It seemed that when the flowers were formed, the female portion of the flower was completely enclosed within the male portions, thereby excluding pollen from any other flower. As it turns out, this is not completely true! Some tomatoes boast these inserted stigmas, while others have exerted stigmas, female portions that protrude from the surrounding stamens. These are perfect opportunities for wandering pollinating insects to cross your tomatoes! So again, get up close and personal

with your tomato flowers and see where that stigma lies.

In many tomato varieties, the anther cone completely encloses the stigma, resulting in self-pollination.

Peas are self-pollinating owing to the structure of the flower.

Self-pollinating vegetables include peas and beans, again due to the structure of the flower. They do not have to be isolated from each other, so go ahead and plant as many varieties as you like in your home garden. If you are offering your saved seeds for sale, it's always wise to isolate, to avoid that errant ant that inadvertently introduced a grain of pollen.

"The Birds and the Bees": Plant Life Cycles and Sex

Saving seeds from plants grown as annuals is straightforward. These plants complete their entire life cycle, seed to seed, in one growing season. But biennials require 2 years to set seed, and saving seed from a biennial that sets seed the first year results in future plants that simply go to seed, without producing any edible portion.

Saving seeds from biennials requires special care on the part of the gardener and will undoubtedly require a little experimentation. You will have to determine which vegetables will overwinter in your Rocky Mountain garden. Root vegetables will need to be dug

to select for desirable characteristics, such as root size and minimal zoning (meaning alternating ring colors in the root), and either replanted in place or stored in damp sand in a cool location over winter and replanted in the spring. Either way, it's best to remove the tops and mulch the plants if left in the garden. The following season they will produce a seed stalk from which you can harvest the seeds.

Understanding vegetables' life cycles is important, and so is understanding the plants' sex. There's no point in waiting for that spinach plant to set seeds when it is a male plant. Without belaboring the point, entire plants can be male *or* female (the technical term is *dioecious*), or both (*monoecious*). So can different flowers on the same plant be male (*staminate*) or female (*pistillate*) or both (*perfect*). In the vegetable garden, spinach and asparagus plants are typically dioecious, so we need to be watchful if we want to save their seeds. So get up close and personal and become familiar with your spinach plants, if you intend to save their seeds. Get yourself a good seed-saving book for more details.

A Sampling of Biennial Vegetables

Beet	Celery	Onion	Salsify
Cabbage	Collards	Parsley	Swiss chard
Carrot	Kale	Parsnip	
Cauliflower	Leek	Rutabaga	

Harvesting Seeds

Entire books are written on seed-saving methods, so I'll only briefly outline three different methods.

Harvesting seeds borne in pods (including beans, peas, and brassicas). Harvest mature pods and dry them until they turn brown, then shell and store the seeds in a paper envelope in a cool, dry place. Before storing *Brassica* seeds, soak them in 122°F water (use a thermometer) for 25 minutes (cabbage) or 18 minutes (broccoli, Brussels sprouts, and cauliflower) to destroy seed-borne diseases. Dry seeds after soaking and store as described.

Bag flower heads after pollination.

Harvesting seeds borne on a flower head (including lettuce, endive, and parsley). Cut the seed heads just before they dry, or bag them in place in the garden; old panty hose work well for this. Dry them in a paper bag and shake or rub the seeds to separate them from the stalk. Store them in a cool, dry place.

Harvest seeds from tomato.

Harvesting seeds borne in fleshy fruit (including tomato, cucumber, and squash). Harvest the fully ripe fruit of tomatoes and cucumbers and squeeze the pulp and seeds into a glass container. Add water and let the mixture ferment for several days at room temperature, stirring occasionally. The seeds that are most likely viable will settle to the bottom. Pour off the pulp, nonviable floating seeds, and water, and spread the good seeds in a single layer on a paper towel to dry. Store them in a paper envelope in a cool, dry place. Scrape out the seeds of squash, melon, pumpkins, and peppers and spread them onto a paper towel to dry. Store them as described.

Storing Seeds

Most seeds store well in a cool, dry place and will retain viability for 5 years or more. The following table will give you an idea of how long you could keep seeds before their germination falls below federal guidelines. Even after that you can plant the old seeds successfully by simply sowing a bit more thickly.

Seed Storage Limits

Vegetable	Number of years seed may retain good viability under optimal storage conditions
Broccoli, Brussels sprouts, cabbage, cauliflower, celery, Chinese cabbage, collards, cucumber, eggplant, kale, kohlrabi, lettuce, muskmelon, radish, rutabaga, spinach, turnip, watermelon	5 years
Beet, Swiss chard, mustard, pepper, tomato	4 years
Bean, carrot, peas	3 years
Parsley	2 years
Leek, onion, parsnip, sweet corn	1 year

Checking Germination of Stored Seeds

Check the germination (not vigor) of old seeds, whether you've saved them from your garden or purchased them a year or two ago, by using the "rag-doll test." Count out a number of seeds and place them on a paper towel. The more you use, the more accurate your results. I like to use multiples of 10 for easy math. Fold the paper towel so the seeds won't fall out, moisten it, squeeze out any excess water, and place it in a jar or ziplock bag that you place on the kitchen counter or in the windowsill. After a week, remove and unfold the towel and count how many seeds have germinated. Slow-germinating seeds, like turnip, may take 2 to 3 weeks before you can make an accurate assessment. Count the number that have germinated and calculate the percentage. If it is 50 percent or greater, go ahead and use the seeds for this year's crop. If germination has dropped below 50 percent, then use your judgment; plant more thickly or purchase new seeds.

Check germination rate of old seeds using the tried-and-true "Rag-Doll Test."

Chapter 6

Starting Transplants. . . or Purchasing Them

Rocky Mountain gardeners are faced with many challenges, not the least of which is the short growing season! However, we can cheat the season by planting transplants for many plants that cannot be successfully direct seeded. Some warm-season vegetables that require a long growing season, such as tomatoes, won't even grow for some of us. But many lucky Rocky Mountain gardeners can use transplants, both for those warm-season plants and also cool-season crops such as spring cabbage that are transplanted relatively early in the season to make good growth during cool weather, ensuring a productive harvest.

Purchase your transplants or grow your own. Purchasing plants limits you to relatively few varieties and to sometimes inferior plants sold at stages of development improper for setting out. Growing your own allows you to sow the varieties you want and to grow excellent inexpensive plants. Even new gardeners can grow

their own transplants with a little guidance.

Purchasing Transplants

The best transplants, sometimes called "sets," should be about 6 inches tall, stocky, pest-free, have good green color, and be at the proper stage of development when transplanted to the garden.

What to Look for When Purchasing Transplants

- Stocky plants 6–8 inches tall
- Plants that are not crowded
- Bottom leaves that are not yellow
- No flowers or fruit

Ease of Transplant

Some crops are more easily transplanted than others, due to their ability to rapidly regenerate root tips that may be damaged during

the transplant process, but even those requiring extra care may be transplanted providing they are grown in peat pots, coir pellets, or by other methods that do not require removal of the pot.

There is little point in transplanting plants such as peas, beets, chard, spinach, or carrots, as they are relatively short-season crops that mature easily in our region when direct seeded. Sweet corn is also not usually transplanted since there are sufficient numbers of early ripening varieties to allow for successful direct seeding.

Relative Ease of Transplant

Easy	Moderate	Requires special care
Broccoli	Celery	Cucumber
Brussels sprouts	Eggplant	Muskmelon
Cabbage	Onion	Squash
Cauliflower	Pepper	Sweet corn
Lettuce		Watermelon
Tomato		

(Source: Maynard and Hochmuth 2007.)

Containers

There are a wide variety of containers in which to grow transplants. Styrofoam coffee cups, egg cartons, individual coffee dispensing pods, flower pots, peat pots, coir pellets, multiplant containers like cell packs, or plastic flats are all used. Many of us save and reuse containers for our transplants year after year. That’s great as long as you remember to clean them annually. A good washing with hot water and dish soap, followed by a clear water rinse, then by a rinse in a 10 percent bleach solution, and finally by a final clear water rinse will do the trick. Allow the containers to air-dry.

Use the larger sizes so that plants will not be crowded, or plan to "step up" your transplants into a larger container prior to setting in the garden, if you start with something small. A rule of thumb is to allow about 6–9 square inches of growing space per maturing plant. A 3-inch-diameter pot will provide one plant with about 7 square inches of space. Plants in peat pots or coir pellets may be set into the garden as an intact unit, but be sure that the lip of the peat pot is completely buried, as an exposed lip can wick moisture away from the roots. If your pellet is the style that uses plastic netting to contain the media, slice it in a couple of places just prior to planting. Some coir pellets have a corn-based wrapping material that should decompose in the soil. Remove plants from plastic pots and Styrofoam cups before transplanting. If the root ball is large and the roots crowded, gently break the ball apart or make several light scoring cuts along the edge of the root ball before planting. This stimulates new root formation.

Before setting a transplant to the garden, gently spread the roots, scoring large root balls if necessary.

Growing Media

Growing media must supply good drainage and yet have adequate water-holding capacity, be free of harmful substances (including pests and weed seeds), and be inexpensive and available. For years gardeners used topsoil amended with sand and peat moss and pasteurized it in the kitchen oven. You could make your own blend, but it's less expensive to purchase your media.

One cubic foot of media will fill about two hundred seventy-five 21/2-square-inch peat pots, sixty 4-inch-round peat pots, or twenty cell packs measuring about 5 x 8 x 23/4 inches. Some seed-germinating media has no nutrients and is used strictly until germination occurs and the seedling is up and going, so read the label! Actively growing seedlings and young plants need nutrients, and if the media does not supply them, you must. Step up your seedlings into a media that has a nutrition charge indicated on the label, but even that will be used up in the early stages of growth. You will need to add more fertilizer as the plants grow. The need for more nutrients will be indicated by the plant foliage turning a yellow-green or purple, but don't wait to see that. Dissolve 2 level tablespoons of 20-20-20 or equivalent high-phosphorus-content fertilizer in 1 gallon of water and apply this weekly during regular watering.

Sowing

Water media thoroughly the night before sowing. If you use flats, sow enough seeds to obtain about 8 plants per inch of row; if you use peat pots, sow 2 or 3 seeds per pot. Thin excess plants later by snipping with scissors so the roots of the plants being kept are not damaged by pulling out its neighbor. Sow most vegetable seeds about twice the depth of the seed's widest dimension, but read the package. Many tiny seeds require light to germinate and need only sit on the media surface. If media is dry after seeding, water it but do not soak it. Bottom watering will avoid disturbing newly sown seeds.

When seedlings emerge after a week or two, they will require light and a slightly lower temperature than that used during germination. This, of course, is most relevant if you grow the transplants in your home and becomes a moot point if you use a

cold frame or hotbed for the plants. While there is an optimum temperature for seed germination and plant growth for every vegetable, they will often do just fine under a wide range of temperatures, so don't worry if you have no way to regulate it.

Some gardeners place heating pads beneath the flats or pots to increase root-zone temperatures, thereby increasing speed of seed germination and growth rate. This is useful but not necessary. Monitor carefully the air temperature at which the sets are grown. A high temperature can cause plants to become leggy, especially in low light; too low a temperature slows growth, induces premature seed stalk formation (bolting) in brassicas and causes the first fruits of tomato plants to be rough and unattractive. Plants grow best if nighttime temperatures are 5–10°F cooler than daytime temperatures.

Seed-starting light tables needn't be fancy.

No matter what some books and magazine articles say, the south window in our region in March and April often does not supply

sufficient light for good transplant growth. Supplement or replace natural, early-season sunlight with fluorescent and/or grow lights. Keep them on for about 12 hours each day, placing them only a few inches above the tops of the seedlings. There is currently a move toward LED lights for growing transplants; however, at this writing, they are prohibitively expensive for most home gardeners, and relatively untested. I'm trying one bank of lights in my home light table as I write this.

Thin plants when they are about an inch tall and still in the cotyledon stage, that is, before the first true leaves emerge. Moisten the media before thinning and, if the plants removed during this operation are to be themselves transplanted, fill new pots and moisten that media before "spotting out" or "pricking off" operations begin. Punch a hole in the new media with a pencil, and then gently tease out the plants to be spotted out with a plant label or tweezers and transfer them to the pencil hole in the new media. Hold the plants by their cotyledons only to avoid crushing their stems. Press media around the roots firmly and water the pots or flats when they are full. Extra seedlings that will not be transplanted should be cut out with scissors and discarded or added to your salad.

Thin plants grown in flats so that they stand at least ½ inch apart after the first thinning. As the plants continue to grow, thin them repeatedly so that by the last thinning they are standing a few inches apart in all directions, allowing about 6–9 square inches per plant.

Watering

To determine when to water your transplants, take a bit of media from the top ½ inch and squeeze it between your thumb and forefinger. If water runs out of it freely, the media is moist enough. Overwatering promotes weak growth and damping-off. Always use water kept at room temperature for watering your transplants.

Time Needed to Grow Transplants

A common mistake is to start your transplants too early in the season. The large plants that result suffer greater transplant shock and will yield poorly. Transplant tomatoes, peppers, and eggplants to the garden before they are ready to bloom. Remove early-set fruit

at the time of transplant to improve subsequent fruit development. Set cucurbits to the garden when their leaves are about 2 inches across. Follow the guidelines in the following table when starting your transplants. For example, cucumbers require about 4 to 5 weeks to grow to transplant size. If you set them to the garden on June 1, then you should start them in late April or early May.

Transplants may also be successfully grown in hotbeds and cold frames. See chapter 11 for more details and information on how to do this.

Approximate Length of Germination and Approximate Time Needed to Grow Good Transplants

Note: The actual time needed will vary by temperature, fertility, and light conditions.

Vegetable	Germination (days)	Growth to transplant size (weeks)
Broccoli	3–4	4–6
Brussels sprouts	3–4	4–6
Cabbage	3–4	4–6
Cauliflower	3–4	4–6
Celery	14–21	10–12
Cucumber	6–10	4–5
Eggplant	7–14	8
Lettuce	4–10	3–4
Muskmelon	4–8	4
Onion	10	9–11
Pepper	5–7	8
Squash/pumpkin	6–10	4–5
Tomato	4–9	5–6
Watermelon	3–12	4

Hardening Off

Plants that have spent their entire lives in a protected environment

where they wanted for nothing are ill adapted to the garden, so before setting them out you need to acclimate or harden them to the outdoors. Hardening off involves a slowing of growth and a toughening of the plant tissues to better enable them to withstand drought, wind, and cold. The process takes about 2 weeks.

When they have reached transplant size, move them outdoors during warmer days and bring them in at night, gradually increasing the length of time they spend outdoors until they remain outdoors day and night for a week before transplanting. During this time decrease watering to provide only enough to keep the plants from wilting. This reduction in water induces the plant to thicken the waxy cuticle layer of its leaves and stems, giving it more protection from drought and wind. If plants were grown in flats, cut the media into small blocks containing a single plant. "Blocking" reduces temporarily the total functional root surface of the plants but causes a proliferation in root branching, which in a short time increases the total root surface substantially. Do not block cucurbits or other plants that are difficult to transplant. For the first week of hardening, give plants partial shade; thereafter, provide them with full sunlight. The stems and leaf veins of well-hardened plants will normally turn purple. Last, withhold fertilizer during the hardening process to force the plant to decrease vegetative growth, making the stem more woody and the plants stockier to better resist wind whipping in the garden.

There are different levels of hardening; some plants tolerate only a small amount of hardening, some a great degree of hardening, and some no hardening at all. Consider the following before you start the hardening process:

- Broccoli and cabbage can be hardened to withstand a frost, but repeated chilling of young transplants at 50°F or lower can cause plants to bolt after planting to the garden.
- Brussels sprouts and cauliflower can be hardened to withstand a frost, but inadequate water and crowding of the young plants can cause the stems to become woody and the buds or curd to develop poorly. Grow both species in individual peat pots to avoid crowding.

Selected Disorders Affecting Transplants

Description	Possible causes	Correction
Leggy, spindly plants	Not enough light	Use full-spectrum lights.
	Excessive watering	Do not allow transplants to sit in water; maintain moist but not wet media.
	Excessive fertilizer	Apply according to label directions; reduce concentration.
	Plants too close together	Provide each seedling with enough room to allow for stocky growth.
Dwarf plants	Look for symptoms of nutrient deficiency (below).	Apply fertilizers often and in low concentrations.
With discolored leaves: Stems and undersides of leaves may be reddish. Leaves may be small. Roots may be stunted.	Phosphorus deficiency	Apply a high-phosphorus starter solution according to label directions.
Lack of green color in leaves and stems; slow growth	Nitrogen deficiency	Apply nitrogen fertilizer solution according to label directions.
With discolored leaves and discolored roots: Plants may wilt in bright sunlight. Lower leaves turn yellow and drop.	Too much fertilizer	Leach excess fertilizer by running clean water through the media.

Description	Possible causes	Correction
With discolored leaves and discolored roots	Too long / too hot sterilization of media	After sterilization of media, soak or leach the soil.
With discolored leaves and no root discoloration	Temperatures too low; growth is slowed.	Maintain proper air and soil temperatures.
Rotting and collapse of the stems near soil surface	Damping-off; fungal organisms in media attack germinating seeds and young plants.	Do not use garden soil that has not been sterilized; wash all reused pots in soap and water, rinse with bleach solution, then water.
Slow root growth	Soil mixture problems, poor drainage, low fertility, high fertility, low temperatures, herbicide residue in soil mix	Adequate drainage, steady supply of nutrients, adequate moisture, appropriate temperatures
Algae and moss growth on media surface	High moisture content of media; poor media mix, poor aeration	Water in the morning; increase air movement around plants; add coarse sand to loosen media.

(Source: Fletcher 1975.)

- Lettuce and onions are easy to grow and can be hardened to tolerate light frosts.
- Cucurbits should be started in individual containers and their

roots disturbed as little as possible during transplanting. They cannot be hardened to withstand even light frosts. Do not thin plants by pulling some, which may damage roots of remaining plants. Rather, pinch or snip out excess plants, leaving their roots intact.

- Peppers can be hardened only slightly, but be sure to keep the temperature above 50°F at all times during the process.
- Tomatoes can be hardened slightly at temperatures above 50°F before their first flower cluster opens. Overhardening will delay plant establishment in the garden and cause rough fruit on the early clusters. Container-grown transplants usually produce fruit earlier than those grown in flats.
- Eggplants cannot be hardened as the process will result in low-quality fruit.

Many good gardeners relish the opportunity to start growing their garden before the snow is gone! Starting your own transplants allows you to select the varieties you want and will give you the satisfaction of watching your plants grow from seed to fruit.

Chapter 7

Planting Time

It's time. You understand the challenges facing you, planned your garden, purchased your seeds or started transplants, and now it's time. After you've read this chapter and found your favorite vegetables' planting requirements in the second half of this book, it'll be time to go down to the garden!

Getting Your Hands Dirty

Prepare the seedbed after the soil has dried sufficiently to work (when it no longer sticks to gardening tools), turning over the top 8 inches to incorporate fertilizers and organic matter and to remove weeds and stones, then bring the surface to a fine, smooth texture by raking and leveling with a steel garden rake. If you don't, small seeds will get buried beneath the clods. Mark rows, leaving enough space between them to accommodate the mature spread of your plants. Row orientation doesn't matter a great deal, but north–south is usually recommended.

Vegetables that produce weak seedlings, such as beets, carrots, and parsnips, are damaged by soil crusting and are very susceptible to weed competition. After sowing, cover the rows with vermiculite or sand to prevent crusting, or plant a nurse crop of radishes with these seeds.

Soil Temperature

Spring fever can be deadly (to plants). Don't be in a hurry to plant into cold soil. Crops planted too early will take a long time to grow, and those same crops planted just a week or two later in warmer soil will catch up with those planted earlier. Years ago, English gardeners used to determine when the soil temperature was warm enough for planting by dropping their drawers and sitting on the soil surface. If the temperature felt comfortable, then the soil temperature was right. I suppose you could also use your wrist, but a much better way is to purchase and use a soil thermometer.

Every plant has an optimum soil temperature for best growth. The following table gives the ideal temperature for germination of

vegetable seeds and seedling emergence from the soil. Soil temperature for germination is measured about 2 inches below the surface. You can purchase a soil thermometer to check temperature or simply use any spare thermometer you have.

Last Frost Date

Avoid books that try to tell you what to do in the garden by date. Our Rocky Mountain region is much too diverse for those to work well. You can determine when to plant the garden in spring by noting the average date of last frost for your area. Fall plantings can be based on the average date of first frost. Be aware however that you are dealing with *average* dates. Experienced gardeners know that those can vary by plus or minus 2 weeks, depending upon yearly and local conditions. Use the table on page 72 as a guide but base your actual time of planting on how the season "feels" to you. If you are a novice, spy on your experienced gardening neighbors or, better still, get to know them and follow their advice. They know your local growing conditions better than any other resource. After gardening for several years, you will know intuitively when the time is right.

Optimum Soil Temperature for Direct-Seeded Germination and Seedling Emergence

Vegetable	Optimum soil temperature for seed germination (°F)	Approximate number of days for seeds to emerge
Celery, spinach	70	4–7
Lettuce, peas	75	2–13
Beans, carrot, cauliflower	80	5–6
Beets, cabbage, eggplant, peppers, radish, Swiss chard, tomato, turnip	85	1–8
Corn, cucumber, squash, watermelon	95	3–6

(Source: Adapted from Maynard and Hochmuth 2007.)

Because tender and very tender crops grow most during warm weather, try to plant them as early as possible without jumping the gun. If you plant them too late, they may spend the last third of

their lives trying to mature a crop when the weather is too cool.

With our short seasons, you may find it difficult to harvest a fall crop from a succession planting. Still, by selecting the right cool-season crop, which must tolerate both the heat of summer planting and the cool of fall maturing, you may have some great success. Beets, collards, kale, lettuce, mustard, spinach, and turnips produce a healthy fall crop if planted 6 to 8 weeks before the average date of the first fall frost.

Planting Times Based on Vegetable Plant Hardiness and Average Last Frost Date

Hardy (4–6 weeks before last frost)	Half-hardy (2–3 weeks before last frost)	Tender (just after last frost)	Very tender (2 weeks after last frost)
Asparagus crowns	Beet	Bean, snap	Cucumber
Collards	Broccoli*	Corn	Eggplant*
Horseradish roots	Cabbage*	Summer squash	Muskmelon
Kale	Carrot	Tomato*	Pepper*
Kohlrabi	Cauliflower*		Pumpkin
Lettuce	Celery and Celeriac		Watermelon*
Onion*	Chinese cabbage*		Winter squash
Peas	Endive		
Rhubarb crowns	Mustard		
Rutabaga	Parsnip		
Salsify	Potato		
Spinach	Radish		
Turnip	Swiss chard		

* Indicates transplants
(Source: Adapted from Maynard and Hochmuth 2007.)

Depth of Planting

You'll need to thin carrots that are sown too thickly.

Many gardeners plant seeds too deeply. Remember that the only source of energy the seedling has until it emerges from the soil surface is what is stored in its seed. The smaller the seed, the less stored energy and the less deeply the seed should be planted. In general, plant small seeds like carrots and lettuce about 1/4–1/2 inch deep and larger seeds like squash, corn, beans, and peas about 1–2 inches deep. If the soil is heavy, cold, or wet, plant a little less deeply to take advantage of warmer surface temperatures. If it is sandy, hot, or dry, plant a little more deeply to take advantage of cooler, moister soil. (Read additional information in The Vegetables section.) Cover the seed with fine soil and tamp it firmly to provide good seed-to-soil contact. Seeds of the cucurbits are traditionally planted in what is called a "hill." This does not refer to a mound but rather to planting several seeds in a group with each group planted a number of feet apart. In fact, mounding can dry the soil excessively. Once the seedlings are up, thin out all but two. If closely planted, their roots may be intertwined; pinch out or snip the plants to be removed rather than pulling them out and disturbing the roots of remaining plants.

Sowing too thickly is also common; it is difficult to spread small seeds like carrots thinly enough. You can mix small seeds with sand, or use a salt shaker to keep from over-seeding. "Seeds" of beet and chard are actually dried fruits containing several seeds, so it is impossible not to overseed. Seedlings of seeds sown too thickly will be thinned when they are an inch or so tall, and then again when they are somewhat taller in order to provide enough room for the plant to develop and mature. Failure to thin adequately results in stunted, stressed plants that will develop undersized plants and

roots, or no fruit at all. Directions for thinning are given under individual crops in The Vegetables section.

Transplants

A cup of soluble fertilizer high in phosphorus or a handful of wet, rotted manure in the bottom of each hole along with plenty of water will help the plants get off to a fast start. A cloudy, windless afternoon is an ideal time to transplant.

In general, water vegetable transplants about an hour or so before transplanting, then plant them as deeply as they grew in the container. An exception is a leggy tomato plant. If you are faced with such plants, set their root balls about 3–4 inches deep, then bury the plant's stem in a small trench for a few more inches, finally allowing the top 6 inches or so of the plant to stand upright above the soil surface. You may have to prop it up temporarily. Remove all foliage from parts that will be buried. This method effectively shortens the height of the transplant above ground, reducing wind whipping and moisture loss, and allows for formation of an extensive root system as roots will form all along the tomato plant stem. Unfortunately, this planting system does not work as well with other vegetables.

Take a Breath

The garden is in. Take a deep breath and watch the miracle of your seeds sprouting, beans climbing, and pea tendrils clinging to the trellis. Care for your garden as I'll show you, and prepare for a bountiful harvest!

Chapter 8

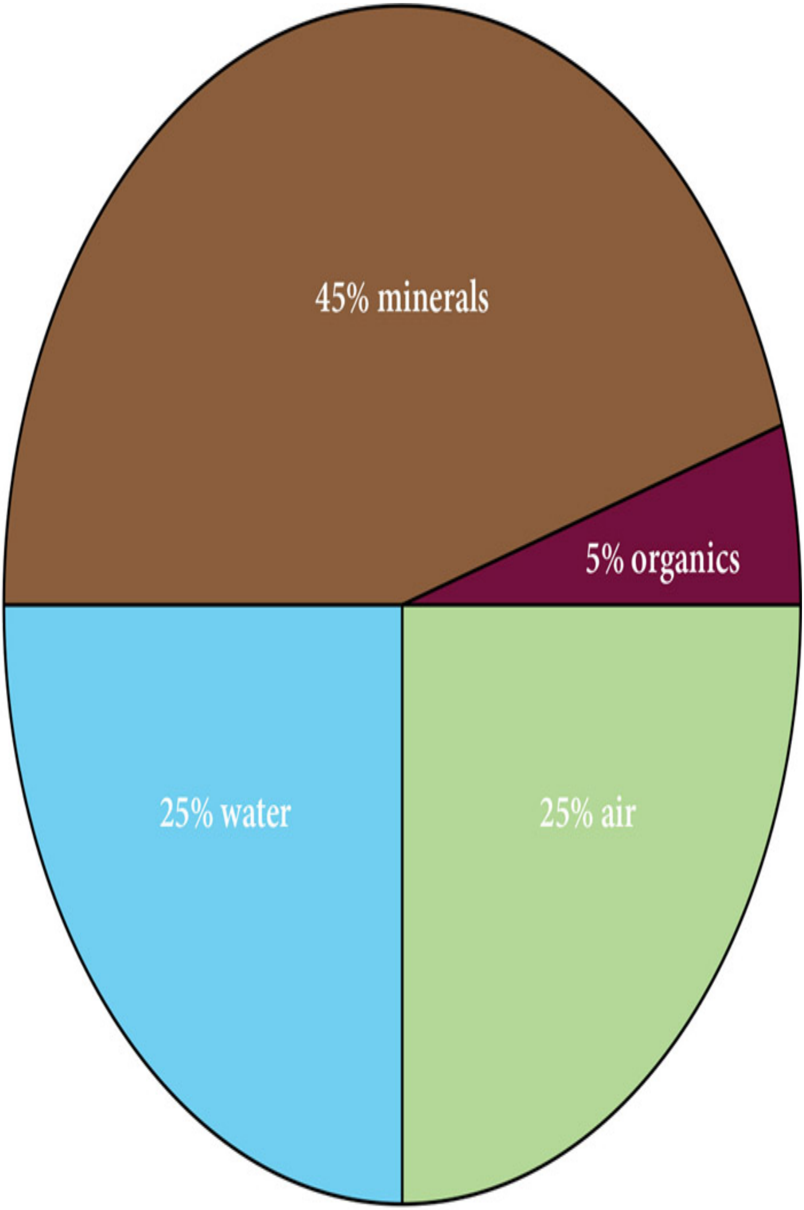
Soil: It's More than Dirt

Unless you plan to garden hydroponically, your plants will be depending on soil. Soil can be rich and easy to work with, but often it is not. Even the best of gardeners have to use whatever soil is in their garden, and if it's substandard, they need to figure out how to improve what Mother Nature gave them, in order to get the garden to produce as it should. The good news is, you can!

Texture and Structure

All soils are mixtures of living organisms, air, water, sand, silt, clay, and organic matter. In an ideal soil, air fills about 25 percent of the spaces between soil particles (pore spaces) and water another 25 percent. This proportion makes for healthy root growth, but as the proportions of air and water space shift, the soil becomes too dry or too wet. Organic matter that makes up about 1–5 percent of the volume is the "glue" that clumps soil fractions into larger particles, which in turn create larger pore spaces and fluffier soil. The remaining 45 percent or so of the soil volume is composed of

various proportions of mineral fractions (sand, silt, and clay). These fractions give the soil its “texture.”



Constituent parts of an ideal soil.

Sand particles can be relatively large and make large pore spaces. As the amount of sand in the soil increases, the water- and nutrient-holding capacities of the soil decrease, while the workability of the soil increases. Sandy soils warm more quickly in spring, allowing you to plant earlier. They also dry out more quickly and need greater attention to watering. Soils high in the clay fraction have small pore spaces, hold more water and nutrients, and remain cooler in spring, delaying planting. They are relatively poorly drained, tougher to work, and easily compacted, further decreasing pore size and restricting aeration to the roots. This reduces the rate of root growth and subsequently top growth of the plants. The silt fraction is midway between sand and clay in size.

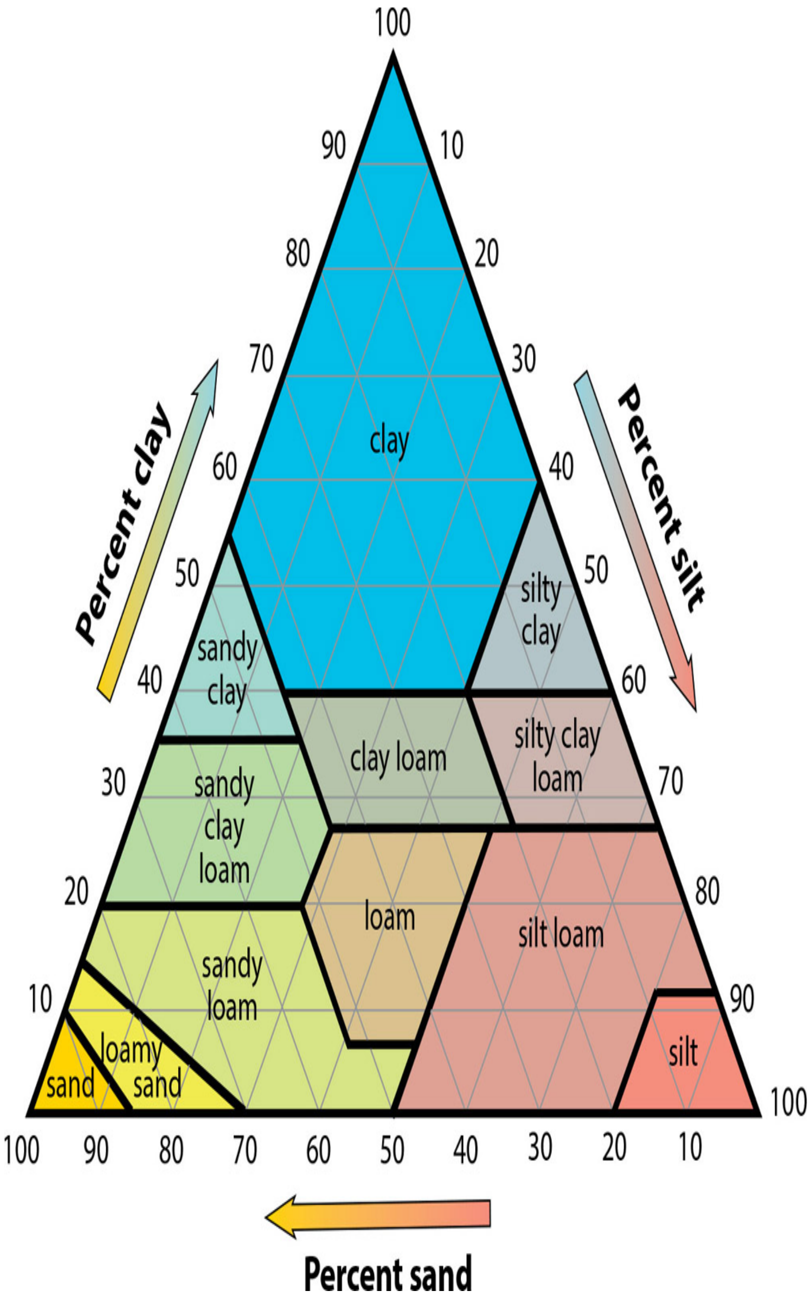
Soils that are composed of approximately twice as much sand and silt as clay are called “loams” and are overall the best garden soils. Loam slightly higher in sand is called “sandy loam,” that which is slightly higher in clay, “clay loam,” and that which is slightly higher in silt, “silt loam.” Sandy loams feel gritty when moist, silt loams more slick. Sandy loams and silt loams are the “best of the best” soils. Wouldn’t it be nice if we were all blessed with one of these soils!

It’s important to know your soil texture. Contact your local extension office or look online to locate a soil-testing laboratory and send them a sample for analysis. The lab report will give you much information, and among the items you can select will be soil texture. But you (and your kids!) can do a fun and inexpensive textural test yourself. Fill a glass or plastic jar halfway with a soil sample from your garden, then the rest of the way with water to which a little powdered dishwasher detergent has been added. Cover, shake vigorously, and then set the jar aside. Soil fractions will settle out in layers, the heavier sand first, then the silt, and finally the clay. The clay remains in suspension for a long time and may take months to settle out, until then the water will look cloudy. The organic fraction will float. With the proportions of sand and silt only, you can use the soil triangle [see next page] to determine its texture.

Easy Soil Texture Test

Look at the combined thicknesses of each mineral fraction and estimate the percentage of individual portions. For example, if the sand layer appears to represent about 25 percent of the total soil, then you can assume your soil is about 25 percent sand. Estimate the silt portion and use the soil triangle to determine your texture type. For example, your soil is approximately 40 percent sand and 40 percent silt. Locate these numbers on the appropriate triangle side and follow the lines for each. Where they intersect is in the loam soil section of the triangle. If the percentages were 70 percent silt and 20 percent sand, then you would have a silt loam soil.

The Soil Texture Triangle



You must know your soil texture in order to know what materials to add to improve it.

Organic Matter

All garden soils need organic matter, the “glue” that bonds small soil into larger particles. This increases pore space and the ability of the soil to maintain good air- and water-holding capacities. Organic matter lightens heavy soils (those higher in silt and clay) and helps sandy soils hold more water. The increased aeration it provides increases bacterial action, which liberates more nutrients from the organic material during decomposition. In addition, organic matter reduces the loss of nutrients through leaching. In short, organic matter improves soil tilth and improves plant growth.

Most soils contain less than 5 percent organic matter. Additionally, organic matter is decomposed by soil microbes over a period of 6–12 months and must be replenished annually to maintain good tilth. But applying too much organic matter is just as bad as applying not enough. Excessive amounts of fresh manure can burn plants, compacted layers of organic matter interfere with penetration of air and water into the soil, and nitrogen used during the decomposition process can result in insufficient amounts being available for plant use.

Whatever organic material you use, incorporate it into the soil at rates of about 25–50 percent by soil volume. That is, spread a layer of organic material 2–3 inches deep over the entire garden and till it into the top 6–8 inches or so of soil. But even as little as a 1/2-inch layer of compost can improve your garden. Sprinkling organic matter over the garden like commercial fertilizer does no good whatsoever. If your organic material is especially woody, like corn stalks and rotted sawdust, sprinkle 1–2 pounds of nitrogen per 1,000 square feet (20–40 pounds of 5-10-10) over the material before you incorporate it into the soil. This will help with decomposition.

Testing Your Soil’s pH and Nutrients

Home soil-test kits are fairly accurate and can be used between professional tests, particularly if you suspect a problem with soil pH or a deficiency of nitrogen, phosphorus, or potassium.

Have your soil tested professionally every 3 years or so. You can test your soil in fall, after harvest, or in spring, prior to planting. Remove the top 2 inches of soil in several spots in the garden, as it may contain litter that will affect your test. Then, sample soil from 4–6 inches below the surface. Take several cups of soil from different parts of the garden, mix them in a bucket, and take a cup of the combined soil for testing. Submit the sample to one of the many soil-test labs around the region and, for a modest price, you should receive a fairly complete and understandable soil analysis, which you can use to improve your garden.

Reading a Fertilizer Label

Labels on fertilizer packages give you lots of information. For example, all labels display three numbers, separated by hyphens, which is the fertilizer analysis or grade. A common garden fertilizer is 5-10-10. The first number (5) tells the percentage of elemental nitrogen the fertilizer contains; the second number (10) is the percentage of phosphorus pentoxide, and the third number (10) shows the percentage of potassium oxide, or "potash." (These are represented by the letters "N-P-K" found on a fertilizer bag, which are the chemical shorthand for nitrogen [N], phosphorus [P], and potassium [K].) The remainder of the ingredients is often a carrier, used to evenly disperse the nutrients, but sometimes other nutrients are present. If that's the case, they will be listed individually. Commercially bagged composted cow manure may have an analysis of 1-1-1, meaning it contains 1 percent nitrogen, 1 percent phosphorus pentoxide, and 1 percent potash. You can immediately see that the cow manure fertilizer is far less concentrated than the commercial fertilizer. That means you will have to use more of it to supply equivalent amounts of nutrients.

The proportion of the numbers in the analysis to each other is called the "ratio." For example, a 5-10-10 analysis has a ratio of 1-2-2. This is important when dealing with various kinds of vegetables. For example, leafy crops benefit from fertilizers with slightly more nitrogen than phosphorus or potash. In that case, a fertilizer with a ratio of 2-1-1 and a grade of 10-5-5 may be more appropriate.

The nitrogen in fertilizers may be in a rapid release or slow release form. Slow release nitrogen fertilizers like Osmocote release nitrogen over a long period of time and, since we are dealing with very short growing seasons in many areas, are probably not the best choice for most vegetable gardeners in the Rockies. Organic fertilizers like manure and blood meal also release their nitrogen to the soil over a relatively long period of time. This is because they depend upon soil microorganisms to break their relatively large organic molecules into smaller molecules that plant roots can absorb. By the time the nutrients in organic fertilizers can be used by the plant, they are in precisely the same form as the nutrients in the commercial fertilizers. Because the microbial action takes some time, organic fertilizers are said to be "slow-acting" or "slow-release" and therefore less apt to "burn" crops. Also, because microbial activity increases as soil temperature increases, that

activity is relatively slow in the cold soils of early spring. If you use organic fertilizers exclusively, your plants may suffer from early-season nutrient deficiencies, particularly nitrogen and phosphorus. Fertilizers that burn plants do so because of their concentrated salt content, which dehydrates plant tissues. Because commercial fertilizers are highly concentrated, with higher salt contents, they can rapidly dehydrate the plant if they come into direct contact with the plant's stem, foliage, or roots. But so can steer manure gathered from feedlots where salts concentrate.

It is important to remember that all types of fertilizers have their pros and cons; no one type is right for all situations. If you are a purist organic gardener, then use the liquid organic fertilizers when soils are cool. If you are not a purist, then use a commercial fertilizer in cool soils and either commercial or organic fertilizer as soils warm in summer. When you apply a summer organic fertilizer, be sure there is still enough time in the season for the material to break down and release nutrients to the plant.

Nutrient Needs and Sources

We all think we know the differences between “organic” and “inorganic” materials, but they are not clearly defined. To the chemist, an organic substance contains carbon, but to the gardener an organic substance may or may not contain carbon. But generally it's a compound that was derived from a once-living organism or is found naturally. For example, manure, compost, and blood meal all contain carbon and were derived from once-living creatures. However, sulfur, gypsum, and rock phosphate do not contain carbon and were never part of a living organism, but all are considered “organic” compounds suitable for use in an organic garden. So the term *organic* has more than one meaning. Most folks who define themselves as organic gardeners use only approved “organic” fertilizers, that is, those that are not highly concentrated and processed and are “natural.”

A smorgasbord of amendments and fertilizers awaits you at the garden center.

Whatever the source and whatever your philosophy, vegetable plants need seventeen essential nutrients to remain healthy. Carbon (C), hydrogen (H), and oxygen (O) from air and water are three used by plants in large amounts. In fact, about 90 percent of the plant is made up of these three nutrients. Plants absorb the remaining thirteen or fourteen nutrients from the soil. Those used in relatively large amounts by plants include nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg). The first three, expressed in the three numbers of a typical fertilizer analysis, are the ones most often lacking in garden soils. The remaining nutrients—manganese (Mn), iron (Fe), zinc (Zn), boron (B), molybdenum (Mo), copper (Cu), and chlorine (Cl)—are used by plants in small amounts and are called minor nutrients. Cobalt (Co) and nickel (Ni) are needed by some plants but not by others, and their necessity in the vegetable garden has not been established. Most minor nutrients are available in soils in amounts sufficient for plant growth, but some, like boron, may be limited. Do not add the minor nutrients to your soil on a regular basis unless you are sure they are needed, as there is a very fine line between their deficiency and toxicity.

Since vegetables remove some nutrients from the soil each year as they are harvested, those nutrients must be replenished annually to maintain productivity. You can do so by fertilizing with a

complete inorganic fertilizer such as 5-10-10. Broadcast this, or spread it evenly, at the rate of about 20 pounds per 1,000 square feet just before planting and till it in. This will get the plants off to a quick start. As the growing season advances, the nutrients added before planting may become depleted or immobilized in the soil. To keep longer-season plants growing vigorously, spread more fertilizer in a band about 8 inches from the base of the plants; this is called side-dressing. A half-handful of fertilizer spread completely around individual plants like cabbage and tomatoes should be sufficient. If you are fertilizing row crops like carrots or beets, spread enough fertilizer along the row so that it looks like a light dusting of snow. Five pounds of 5-10-10 per 100 square feet, or a handful per 10 feet of row, should be just about right. Usually one or two side-dressings per season for long-season crops are enough.

Inorganic or so-called commercial fertilizers are concentrated and inexpensive, but they contain no organic matter, a valuable constituent in all garden soils.

Foliar fertilizers are useful for supplying minor nutrients. They are easy to use, but because of this you can get into trouble by applying them too frequently. Usually high in nitrogen, over-application of these fertilizers tends to promote excessive leaf and stem growth and delay ripening. The result can be 20-foot-tall tomato plants with hundreds of small, green fruits that do not ripen. Take it easy when using foliar fertilizers.

Organic fertilizers are bulky and less concentrated than inorganic fertilizer and hence have to be added in larger amounts. However, they sometimes contain large amounts of valuable organic matter. The following table lists some organic fertilizers and the amounts that should be added to the garden per application. Do not use pet or other carnivore manures as they may harbor diseases and parasites. Also, try to spread manures and compost on the garden in the fall, and till them in. “Cold” manures are usually high in moisture and decompose slowly; “hot” manures decompose rapidly and can cause severe burn when used directly on crops.

Common Organic Fertilizers

Note: All analyses are approximate.

Material and analysis	Pounds to add per 1,000 square feet of garden*	Notes
Blood meal (dried blood) 13-0.9-0.8	10	Expensive, strong odor; may attract predators
Cottonseed meal 7-3-1.5	50	Expensive; may be unavailable
Cow manure (dry) 1.5-2-1.2	200	Expensive
Cow manure (fresh) 0.5-0.2-0.5	500	Bulky; odor; cold manure; compost fresh manure
Chicken manure (dry) 4.5-3.5-2	100	Odor when wet; may cause excessive vegetative growth
Chicken manure (fresh) 1.5-1-0.5	200	Ammonia can burn young plants; may cause excessive vegetative growth; hot manure
Compost 2-1-1	60	Apply a layer up to 3" deep
Feather meal 12-0-0	10	Nitrogen slowly available; hard to find
Fish meal 10-3.8-0	15	Nitrogen and phosphorus slowly available; odor; may attract predators
Greensand (glauconite) 0-1-7	150–300	Potassium slowly available; high in micronutrients; apply to gardens every 3–4 years.
Horse manure (fresh) 0.7-0.3-0.5	500	Bulky; may contain many weed seeds; hot manure
Pig manure (fresh) 0.7-0.6-0.7	500	Odor; bulky; cold manure
Rabbit manure (fresh) 2-1.3-1.2	150	May be available in insufficient quantities; hot manure
Sheep manure (fresh) 1.4-0.7-1.5	300	Easy to handle; may cause excessive vegetative growth; hot manure
Sheep manure (dry) 4.2-2.5-6.0	100	May cause excessive vegetative growth

Material and analysis	Pounds to add per 1,000 square feet of garden*	Notes
Steamed bonemeal 2-12-0	15	Expensive; may require several years for phosphorus to become available to plants in alkaline soils
Rock phosphate 0-30-0	150–300	Dusty; 33% calcium; phosphorus nearly unavailable in soils above pH 6; hard rock phosphate contains about 33% P_2O_5, colloidal rock phosphate about 22% P_2O_5. Apply to gardens every 3–4 years.
Wood ashes 0-1-5	20	23% calcium; raises soil pH over time

* One bushel of manure weighs about 50 pounds. For manures, apply about 4 to 5 wheelbarrow loads per square rod (272 square feet) of garden. Apply an additional 2 pounds of phosphorus (20 pounds of 5-10-10 or 15 pounds of steamed bonemeal) per 1,000 square feet when using any fresh manure. Suggested rates of application are approximate and intended as guides only.

Common Inorganic Fertilizers

Note: All analyses are approximate.

Material and analysis	Pounds to add per 1,000 square feet of garden	Notes
Mixed fertilizers (5-10-10, 10-10-10, 16-16-16, etc.)	9–18	Best applied broadcast before planting, in bands at planting, or as side-dressing
Monoammonium phosphate 11-48-0	8–10	One of the best fertilizers to band at planting
Ammonium phosphate 16-20-0	4–8	Excellent for side-dressing
Superphosphate 0-20-0	5–8 banded; 8–16 broadcast	Excellent source of phosphorus; broadcast and turn under when using large amounts of manure.
Treble superphosphate 0-45-0	4–6 banded; 5–10 broadcast	All phosphorus sources should be placed close to the root zone since phosphorus does not move much in the soil.

Buyer Beware

Many books, catalogs, and garden centers sell fertilizers packaged as "asparagus food," "tomato food," or "carrot food." These are marketing ploys, and many times the various "foods" do not differ significantly in analysis among themselves. Yet they often sell for high prices, and you will accumulate untold numbers of bags of the different "foods" at needless expense. Leave the specialty foods on the shelves and purchase a bag of inexpensive 5-10-10, or a bag of blood meal for your garden.

How to Calculate Fertilizer Equivalencies

Books and magazine articles will often say to apply a certain fertilizer or its equivalent. What does that mean and how do you calculate equivalencies? Let's take two fertilizers, say a bag of 5-10-10 and a bag of 10-6-4. Both have nitrogen in rapid-release form and contain no special micronutrients or organic matter. In other words, they both contain only nitrogen, phosphorus, and potassium. When we use the term *equivalent* without qualification, we refer to equivalent amounts of nitrogen, since that is the nutrient used in greatest amounts and the one that is lost rapidly to leaching or volatilization. Since the bag of 5-10-10 contains half the amount of nitrogen as the bag of 10-6-4, we would have to apply twice as much to get the equivalent amount of nitrogen. Now, let's say that the bag of 5-10-10 weighs 25 pounds and sells for $10 and the bag of 10-6-4 weighs 25 pounds and sells for $15. The bag of 10-6-4 supplies twice the nitrogen as the bag of 5-10-10 but sells for less than double the price, so the nitrogen in the 10-6-4 is less expensive than the nitrogen in the 5-10-10. The 10-6-4 fertilizer is the better value.

Most granular commercial fertilizers weigh about 1 pound per pint of material. The following table gives you the amount to apply when recommendations are made in pounds or tons per acre.

Fertilizer Equivalents

Per acre	Per 1,000 square feet	Per 100 square feet	Per 1 square yard
100 lb.	2½ lb. (2½ pints)	¼ lb. (½ cup)	½ oz. (2½ tsp.)
2,000 lb. (1 ton)	50 lb.	5 lb. (5 pints)	½ lb. (1 cup)

Let's continue with equivalencies. You read a recommendation that 1 pound of *actual* nitrogen be applied per 1,000 square feet of garden. How much 5-10-10 must you spread to apply 1 pound of *actual* nitrogen? Divide the percentage of nitrogen as a whole number into 100: $100 \div 5 = 20$. Therefore, you must spread 20 pounds of 5-10-10 to apply 1 pound of actual nitrogen. Now, say your neighbor gives you a bag of ammonium sulfate with an analysis of 21-0-0. How much of that must you spread to apply 1 pound of actual nitrogen? Doing the math, we get $100 \div 21 = 4.76$, which we can round to 5 pounds. We might also have rounded 21 to 20 to simplify the arithmetic because it is a waste of time to deal with 1/4 pound of fertilizer over 1,000 square feet.

Fertilizer equivalencies usually require more thought than the above examples. For example, you have some 5-10-10 and some cow manure. You want to fertilize 1,000 square feet of garden. How much cow manure must you apply to get the equivalent amount of nitrogen in the 5-10-10? We know that 20 pounds of 5-10-10 will supply 1 pound of actual nitrogen. According to the table, dry cow manure contains about 1.5 percent nitrogen. Therefore, we must apply $100 \div 1.5 = 66.6$ pounds of the dry cow manure to supply 1 pound of actual nitrogen. However, the 5-10-10 and the cow manure are not equivalent since the cow manure adds slow-release nitrogen and organic matter to the soil whereas the 5-10-10 does not. It's fine if you consider only the nitrogen, but the organic matter is very important for the health of the soil.

You can figure equivalencies in the same manner on the phosphorus and potassium as well.

Equivalent Amounts

Fertilizer recommendations are often given in pounds per acre, but most of us do not have an acre of garden. To calculate smaller amounts, remember that most mixed, commercial fertilizers weigh about 1 pound per pint of fertilizer, a cup of material will weigh about 8 ounces, and a teaspoonful of material will weigh about 3/4 ounce. The table above indicates how much fertilizer should be applied to 50 feet of row with different spacings between rows when the amount is given in pounds per acre.

Fertilizer Math

Note: Ounces of fertilizer to apply per 50 feet of row at various distances between rows when the total fertilizer amount is expressed in pounds per acre

	Distances between Rows						
Lbs/ acre	12 in.	18 in.	24 in.	30 in.	36 in.	42 in.	100 sq. in.
100	2	3	4	5	6	7	4
150	3	4½	6	7½	9	10½	6
200	4	6	8	10	12	14	8
300	6	9	12	15	18	21	12
400	8	12	16	20	24	28	16
500	10	15	20	25	30	35	20
600	12	18	24	30	36	42	24

(Source: Tate 1964.)

The Nutrients Plants Need

So, just why is it important to not only apply fertilizer but to apply

the correct combination of nutrients? Just like giving your body its daily balanced vitamins, supplying plants nutrients is vital. Following is a description of how the major nutrients contribute to plant growth and what to look for if they become deficient or present in excessive amounts. Following the name of the nutrient is its chemical symbol.

Nitrogen (N)

Nitrogen strongly promotes vegetative growth of leaves, stems, and roots; leaf crops like spinach require it in large amounts. Nitrogen compounds in inorganic fertilizers are readily available to plants, but those in organic fertilizers must be broken down by microbial action before plants can use them. The ammonium form of nitrogen is volatile and easily lost to the atmosphere but does not leach readily into the soil. Bacteria convert it to the nonvolatile nitrate form, which leaches easily. In compacted soils bacteria convert nitrates back into atmospheric nitrogen, making it unavailable to plants. Bacteria use nitrogen to decay soil organic matter. The more organic matter you add to the soil, the more nitrogen the bacteria must use and the less nitrogen will be available for plant growth. In fact, about half the nitrogen in manure volatilizes and is lost into the atmosphere. About half the nitrogen applied in commercial fertilizers is used by microbes to decompose soil organic matter and is therefore unavailable to plants. So, plants have available to them only about half the nitrogen you apply. Legumes like peas and beans have root nodules containing bacteria that “fix” atmospheric nitrogen into a form available for plant use. Peas fix almost 2 pounds of nitrogen per 1,000 square feet, and beans fix about half that amount. These soil-enriching crops must be turned under and their tissues must decay in order for most of that nitrogen to be released for use by other plants.

Plants suffering from a nitrogen deficiency look stunted and have fibrous, stiff stems and small yellow leaves that drop early. Yellowing appears first on the older leaves (iron deficiency yellowing appears first on the youngest). Flower and fruit production may be scarce, and fruit size is small.

With the overuse of foliar fertilizers, it is sometimes more common to experience an excess of nitrogen. Excess nitrogen shows as luxuriant growth and the overproduction of fruit on plants such as tomatoes, resulting in many small, green tomatoes that fail to

ripen. Ripening is generally delayed on all crops, and foliage and stem growth can be rampant, with stems tending to lack stiffness. Plant tissues will be soft and perhaps more prone to pest infestations and drought.

Phosphorus (P)

Phosphorus promotes root, flower, fruit, and seed development and stiffens plant stems. Much of the phosphorus in the soil is chemically bound and not available for plant growth, especially in soil with a pH above 7. It does not move easily in the soil, and so fertilizers containing phosphorus should be tilled into the top 4–6 inches to be nearer the plant's root zone.

A deficiency of phosphorus delays growth and maturity and causes stems to become thin, short, and purple. The purple color also develops on the undersides of the leaves, eventually progressing throughout the entire leaf, which may become a dull blue-green color. Leaves of some plants may develop a bronze coloration. Fruit on phosphorus-deficient plants may be highly colored, soft, and sour, with poor keeping quality. The number of potato tubers may be reduced. Early-season transplants, especially tomato, often display purple stems and leaves due to the relative unavailability of phosphorus in cold spring soils.

Potassium (K)

Potassium stimulates general vigor of the plant. It promotes root growth and is used by root crops such as parsnips and beets in relatively large quantities.

A potassium deficiency results in development of a gray or buff-colored area near the margins of older leaves. Eventually, the entire margin appears burned, and the leaves may roll. Plants are stunted with poor development of flowers and fruit.

Calcium (Ca)

This nutrient helps build strong cell walls. When stressed for water, some plants may not be able to absorb sufficient calcium, even if it's available, resulting in blossom-end rot in tomatoes and peppers, cavity spot in parsnips, black heart in celery, and cabbage tipburn. Further, excess potassium fertilizer can interfere with the plant's ability to absorb calcium, thereby creating an artificial deficiency of that nutrient.

Magnesium (Mg)

This nutrient is necessary for the production of chlorophyll, the green pigment that facilitates photosynthesis. Soil organic matter and clay particles keep it readily available for plant use.

A magnesium deficiency causes yellowing between the veins on older leaves and premature leaf drop. Sometimes the leaves also take on a brilliant reddish to orange tint. Symptoms often show in midsummer when the stress of a crop load, heat, and drought is most severe. The nutrient may become deficient in acid, sandy soils or if excessive calcium or potassium is added to the soil.

Sulfur (S)

Vegetables need this nutrient to make certain proteins, which give radishes, brassicas, onions, and garlic their characteristic pungency. Sulfur deficiency is rare.

Minor Nutrients

These are seldom deficient in the garden. Where they are deficient soils are usually very low or very high in organic matter or have a very high pH. They may also be deficient in coarse-textured or highly weathered soils. A very high soil pH is usually the main culprit, so take measures to keep your soil as close to neutral pH as you can. Of all the minor nutrients, boron and iron are most often deficient in our soils.

Boron (B). Damage from boron deficiency usually shows as black, sunken spots with dead or water-soaked areas. This is called “brown rot” in turnips and rutabagas, “hollow stem” in celery, and “canker” in beets. Flowering can be reduced, and fruit appear rough and spotted. The stems of brassicas and celery become brittle, cracked, and hollow. Boron is most often deficient in asparagus, bulb and root crops, brassicas, and tomatoes. Apply boron only as directed by a soil-testing lab, as excess boron can sterilize your soil.

Iron (Fe) Iron deficiency is often the result of soil iron being chemically bound and unavailable for plant use due to a high soil pH (as in our region). While nitrogen deficiency causes yellowing of the *oldest* plant leaves, iron deficiency causes severe yellowing of the *newest* leaves on a plant, resulting in poor shoot growth and poor fruit production. Deficiency of this nutrient is actually more commonly found on fruit plants and ornamentals but still can affect vegetables.

There is a fine line between deficiency and excess of micronutrients. Never add these to the soil unless a soil test indicates they are deficient.

Types of Fertilizer

Fertilizers also come in various physical forms. Granular fertilizers are most common. The dry granules are easily spread, easily stored, and freezing is not a concern. Liquid fertilizers should not be allowed to freeze and may precipitate if they get old, losing their nutrient value. These are usually mixed with water and applied to the soil or directly to the plant foliage. The term *soluble fertilizer* is a misnomer, as all fertilizers are soluble. The term is applied to dry fertilizer that is to be mixed with water to form a liquid that is then sprayed directly onto foliage or applied to the soil (as are liquid fertilizers). Since this type of fertilizer is stored in dry form, freezing is not a consideration. Many organic fertilizers are liquid (fish emulsion), dry granular (rock phosphate), or powder (blood meal).

All fertilizers must be dissolved in water before their nutrients can enter the plant roots. Granular fertilizer applied to the soil with no rain in sight and no irrigation does no good at all; it just sits there. Because the process takes some time, dry fertilizers may not affect plant growth for a week or two after application. Whereas dry fertilizers depend upon rain and irrigation to become effective, the gardener dissolves liquid fertilizers and “soluble” fertilizers before application, allowing them to work very quickly to stimulate plant growth. Nutrients sprayed on the foliage enter the plant rapidly and effect a change in a matter of days. However, because these “foliar” fertilizers are very handy and act quickly, they are very popular and often overapplied.

Broadcasting, Banding, and Side-Dressing Fertilizer

Soluble fertilizers are applied to the foliage of the plant with a watering can or a sprayer, or they can be poured onto the soil around the plant. The latter method is safest in that it avoids placement of salts directly onto the foliage. Dry fertilizers can be **broadcast** before or during garden preparation to raise the general fertility level of the garden. In this case the correct amount of

fertilizer is sprinkled on the garden as you would feed scratch to chickens, or spread with mechanical spreaders, then tilled in during soil preparation.

Banding is placement of fertilizer an inch to the side of and an inch below the seeds in the row. This places the fertilizer close to the plant for maximum benefit and minimizes waste.

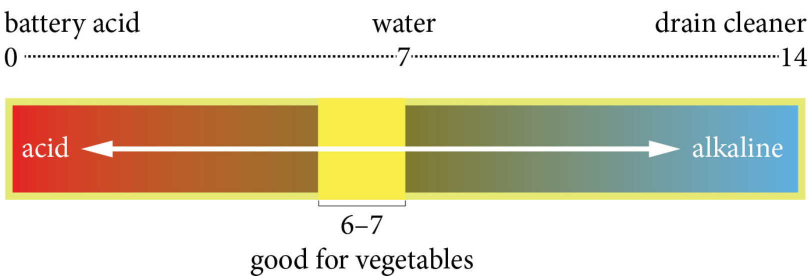
Side-dressing is placement of the fertilizer in a band around the growing plant, as in the case of tomatoes and cabbage, or along the sides of the plants in rows, as with Swiss chard. Side-dressing is particularly important for long-season crops because the fertilizer placed before planting will have been lost or used long before the end of the growing season. If placing around plants, position the band several inches away from the plant's stem to avoid burning the tissue, and continue the band entirely around the plant. Side-dressing may need to be done two or three times throughout the season to keep long-season crops growing rapidly.

The Importance of Proper pH

A fertilizer may contain primarily one nutrient, like rock phosphate, or, like sheep manure and 5-10-10, it may contain many nutrients. How available those nutrients are for plant use depends on microbial activity, soil temperature, and the availability of water. It also depends upon how acid or alkaline the soil is. The degree of acidity or alkalinity is expressed as the pH. The gardeners' pH scale runs from 1 to 14, with 7 being neutral. Values below 7 are acid and those above, alkaline. The scale is logarithmic, so there are

multiples of 10 between numbers. For example, a pH of 6 is 10 times more acidic than a pH of 7; a pH of 5 is 100 (10 x 10) times more acidic than a pH of 7. Most vegetable plants do best in soils that are slightly acidic, with a pH ranging from 6 to 7, although they tolerate wider ranges. However, a soil that is far outside that range, say at pH 4 or pH 8, becomes problematic in that some nutrients become chemically bound and unavailable to the plants. Other nutrients may become toxic. So it is important to maintain your soil pH as close to slightly acid or neutral as possible. In general, soils in areas with higher amounts of precipitation tend to be more acidic and those in areas with lower precipitation more alkaline. If your soil pH is too low, raise it by turning in limestone or wood ash; if it is too high, then lower it by turning in sulfur, ammonium sulfate, iron sulfate, or composted organic material. Low soil pH is not common in the Rocky Mountain region, so you may never have to use limestone. Altering soil pH can be difficult in soils with a high buffering capacity, that is, in soils that contain compounds that resist pH change. Organic matter will lower soil pH very little; vinegar, usually not at all, so save the vinegar for cooked spinach and kale.

The pH Scale



You may have a lab test your soil pH or you may purchase an inexpensive soil test kit that uses a dye to determine pH. Soil pH meters are also available for purchase, but keep in mind the dye method and the inexpensive pH meters may be accurate only to within one pH point.

Amendments

Some soil amendments have relatively little fertilizer value but are highly valued for their ability to alter soil structure, in turn altering the workability of the soil and its water- and nutrient-holding capacities. Pulverizing or finely grinding amendments increases their surface area, thus speeding decomposition and the subsequent availability for plant use. This is particularly important when using rock powders.

Chemically inorganic soil amendments include sulfur, limestone, gypsum, wood ash, and coarse sand.

Pounds of Sulfur to Apply per 1,000 Square Feet to Lower Soil pH to 6.5

Soil pH	Sandy soil	Loam soil	Clay soil
8.5	50	63	75
8.0	30	38	50
7.5	13	20	25
7.0	3	4	8

Pounds of Limestone to Apply per 1,000 Square Feet to Raise Soil pH to 6.5

Soil pH	Sandy soil	Loam soil	Clay soil
6.0	25	50	60
5.5	48	93	115
5.0	65	128	165
4.5	80	160	210

Sulfur adds elemental sulfur, an essential nutrient, to the soil, but it is primarily used to lower soil pH. Prilled (pelletized) or agricultural sulfur is preferred and should be applied in early spring before the gardening season begins. The elemental sulfur reacts with rainwater and snowmelt to form sulfurous acid, which lowers the pH. The sulfur portion of ferrous sulfate and ammonium sulfate will also acidify the soil, and the compounds add valuable iron and the ammonium form of nitrogen.

Limestone (calcium carbonate) is applied to raise the soil pH. Ground limestone contains large amounts of calcium and smaller amounts of magnesium. Dolomitic limestone contains larger amounts of magnesium. If your soil is particularly deficient in magnesium, an unlikely event in our area, use dolomitic limestone.

Gypsum (calcium sulfate) does not substantially alter soil pH but is helpful in amending saline soils. The presence of sodium and other salts in the soil reduces the size of the pore space, making the soil compact, harder to work, and poorly drained. It also can result in water deficits in the plant, restricting plant growth and yield. Gypsum makes the salt more mobile so that it can be flushed out of the soil with rain or a good watering. It will not make soil easier to work unless the difficulty is due to underlying salt problems. Like sulfur and limestone, gypsum should be spread on the soil surface and thoroughly tilled in to do its job. Do not use sheetrock or other construction-grade gypsum.

Wood ashes are high in calcium and potash and are used as a substitute for limestone. Because they raise soil pH, use them with caution, applying no more than a 5-gallon bucket (20 pounds) of the ashes per 1,000 square feet per year unless your soil is strongly acidic. (This is about the amount of ash you get from burning a cord of wood.) Excessive use of wood ash can result in an overabundance of potassium, which in turn may restrict calcium uptake by the plant. This lack of calcium can increase the incidence of blossom-end rot in your tomatoes, squash, and peppers.

Chemically organic amendments are generally of low analysis,

are bulky, and are primarily of benefit in adding valuable organic matter, and improving soil texture and overall soil health. This is something commercial fertilizers cannot do.

Compost is decayed organic matter. It loosens heavy soils and improves root penetration and water infiltration. You can build a compost pile, purchase a compost tumbler, or you can simply till organic material directly into the garden soil and let it rot in place (do not bury diseased plant material or weeds that have gone to seed). The compost pile is something new gardeners want to build as a rite of passage into the gardening world. The building is simple, but the process in the Rocky Mountains can be time-consuming. Our cold nights, short seasons, and dry climate conspire to slow the rotting process, and the final product may take a year or more to achieve. If you cannot make your own compost, it is readily available as a commercial product.

Sod, grass clippings, hay, straw, kitchen scraps, leaves, and even shredded newspaper and cardboard can be composted. Materials such as wood shavings and wood chips can be used, but they rot very slowly. Do not use meat scraps, eggs (although eggshells are okay), fish, animal carcasses, fat, or pet manure in the pile as all add strong odors and may attract unwanted wildlife, and the manure might carry parasites. Use no diseased plants or noxious weeds such as spotted knapweed or field bindweed. Grass clippings from lawns treated with a broadleaved herbicide such as 2,4-D may carry that compound into the compost pile where it is slow to decay and can harm crops when the compost is spread on the garden.

There are a few rules to remember in order to build a successful compost pile:

- The woodier the material, the higher its carbon content and the slower it decomposes.
- The greener and more succulent the material, the higher its nitrogen content and the more rapidly it decomposes.
- The finer the materials, the faster they decompose.
- Optimum composting occurs when the material in the pile contains about 30 parts carbon to 1 part nitrogen. This is called the carbon to nitrogen (C:N) ratio. If your C:N ratio is greater than 30:1 you will have to add nitrogen to help microorgan isms break down the compost.

Carbon to Nitrogen Ratios for Common Materials

High nitrogen ("green") materials	Carbon to nitrogen (C:N) ratio*
Vegetable waste	12–20:1
Grass clippings	20:1
Cow manure	12–25:1
Horse manure	25:1
Poultry manure	10:1
Poultry manure with litter	13–18:1
Pig manure	5–7:1
High carbon ("brown") materials	
Dead leaves	30–80:1
Corn stalks	60:1
Straw	40–100:1
Tree bark	100–130:1
Paper	150–200:1
Wood chips and sawdust	100–500:1

* C:N ratio varies depending upon the amount of bedding in manures and upon the woodiness of plant material.

Commercially available compost tumblers allow gardeners with smaller plots to make good use of kitchen scraps and untreated lawn clippings.

If you build a compost pile, locate it near the garden. Some gardeners build a cage out of poultry wire or even bales of straw to contain the material. Some simply pile the material. However you do it, a standing pile must be *at least* 3 feet wide and 3 feet high in order to work properly; small piles do not heat sufficiently to maintain the process. Piles 3 feet high and 5 feet wide are popular.

Plastic compost bins are becoming increasingly available. They range from mounted tumblers to small plastic "houses" and large

balls you can roll around the garden. Some of these are better suited to our Rocky Mountain gardens than others, while some just don't work. Before you purchase one of these handy-looking devices, consider the space they will take (you'll actually need two to keep the process moving), how (and who!) will be doing the rolling/tumbling/turning, and if it will actually produce enough compost to make your efforts worthwhile. Check with a gardening neighbor or your local extension office to see if they're recommended for your location.

Making Your Own Compost

There are many methods for making compost. Let's discuss three of these. The standard method produces finished compost in a summer. The static method may take a year or more to produce compost, but your inputs will be quite low. The rapid method creates compost in as little as 6 weeks but requires relatively high involvement, requiring that you turn it every 3 or 4 days until internal temperatures drop.

The Standard Pile Method

Gather sufficient green and brown material to make the pile and shred or chip most material that is too coarse (bigger than about 2 x 2 inches). Some corncobs and small branches, however, can help aerate the pile. Spread a 6-inch layer of coarse, high-carbon material on the ground, then add a 6-inch layer of green material. If green material is limited, sprinkle about 2 ounces of actual nitrogen per bushel of brown material to add enough extra nitrogen. These 2 ounces of nitrogen can be supplied by adding 7 ounces of ammonium nitrate, 16 ounces of calcium nitrate, 5.2 ounces of urea, 20 ounces of dried blood, or 24 ounces of fish meal. Mix the fertilizers with organic materials as they are added to the pile. Add water with each layer to wet the material. Test moisture by squeezing a handful of material—it should feel like a moist (not wet) sponge. Continue to add layers of brown and green material until the pile is complete. Several days after the pile is complete, the internal temperature should reach 110°F. Turn the pile after a week, checking the moisture and moving any coarser, drier outer layers toward the center. An easy way to do this is to simply move the pile from one location to another. Mix the pile again in another week,

following the same process. By this time the internal temperature should be between 120˚F and 140˚F and steam should rise from the pile in the cool of the morning. Mix the pile again after another week. Decomposition should have begun, the internal temperature should have dropped to about 110˚F, and the pile may have shrunk to half its original size. By the fourth week the material should look dark and crumbly and have a good, earthy smell. The internal temperature will have dropped even more. Wait another week or two, then screen your compost and use the finer material on the garden. Coarse material that did not break down can be added to the next pile.

The Static Method

This method requires a longer period of time to create good compost. You need not pay close attention to mixing materials in the proper ratio, and only a minimal amount is paid to moisture levels. Build the pile as materials become available but do try to chop and mix the materials before adding them. Allow the materials to break down at their own rate, with little or no turning. After 6 months you should be able to find some compost near the bottom of the pile. This method is very slow but requires little time or effort.

The Rapid Method

This method is labor-intensive, and you will need three bins. Build the pile in the first bin as described above for the standard method, paying close attention to shredding the materials, mixing the proper amounts of brown and green materials, and adding nitrogen, should that be needed. Move it to the second bin after 3 days and be sure to check for proper moisture. Add no new material to this batch. Rather, add to the first bin to start your next batch. Temperatures near the center of the pile should reach about 160˚F, killing disease pathogens and weed seeds. If the temperature exceeds 160˚F, the microbes responsible for decomposition will themselves be killed. If the temperature does rise too high, mix the pile. After 2 weeks of regular turning, the temperature in the second bin will have dropped, and the compost will be brown and crumbly and have an earthy aroma. Move the first batch from the second to the third bin from where you can screen the compost and use it where you wish, returning the coarser materials to the first pile.

Cover Crops or Green Manures

Ounces of seed to sow

Wh

Type	Legume	Ounces of seed to sow per 100 square feet	When to sow	When to turn under	Effects	Notes
Alfalfa	Yes	½	Spring	Fall or following spring	Fixes 150–250 lb. N/acre/year. Roots break hard soil and bring trace nutrients to the surface.	Needs warm temperatures for germination. Sow by August 10 at high elevations. Can become weedy.
Barley	No	4	Spring, fall	Spring, fall	Adds organic matter	Tolerates drought; not as hardy as rye
Buckwheat	No	2½	Spring, summer	Summer, fall	Mellows soil	Occupies part of garden during season; grows quickly, not hardy; attracts bees
Oats	No	4	Spring, fall	Summer, spring	Improves soil aggregation	Not hardy
Rye	No	4	Fall	Spring	Adds organic matter	Very winter hardy
Winter wheat	No	4	Fall	Spring	Improves aggregation	Same as barley

The organic materials and the soil have all the microbes you need to do the job and use of commercial activators or compost starters is not necessary.

Instead of, or in addition to, composting, you should plant a cover crop in unused portions of your garden during the growing season or during winter to hold the soil against erosion and to reduce the amount of weed growth. When these cover crops are turned under, they become “green manure.” It is always a good idea to use green manures to build soil organic matter.

Turning under garden waste at harvest time is an effective way to compost in place.

You may also add organic matter directly to your garden soil without first composting it. Spread straw, peat moss, leaves, and other material directly on the soil surface and turn them under. Alternatively you may dig a trench in an unused portion of the garden and fill it with organic material as it becomes available, backfilling the trench as you go. This is easy and effective, requires little time, and keeps the garden neat and tidy all season long.

Soil is the not-so-secret element to gardening success. Maintaining and monitoring the proper levels of soil nutrients and organic matter is an ongoing process, but doing so will go far in ensuring you have the best vegetable garden possible!

Chapter 9

Watering: Getting It Right

Watering the garden is easy, right? Turn on the ol' oscillating sprinkler and go shopping. But, providing the right *amount* of water at the right *time* to developing vegetables is one of the larger challenges for the Rocky Mountain gardener, and many folks have trouble determining how much water is enough. Most vegetable plants are about 90 percent water, so they need to have plenty. But too much waterlogs the soil, ruins its structure, and compounds your problems. Excess water delays plant maturity, attracts pests, and causes fruit to crack. Mature plants and those with extensive leaf surface need more total water than young plants, and plants with shallow root systems need more frequent watering than those more deeply rooted. Insufficient water stunts and stresses all plants, and leads to poor tipfill (undeveloped kernels at the tip) in corn and poor flower set in tomatoes.

It's obvious that, the higher the temperature, the more water the

plants need. Windy conditions increase water need as it speeds transpiration (water loss from the plant) and soil water evaporation. Early cool-season crops, which make much of their growth during cool weather, need less water than crops that produce in the heat of summer. For example, Bob and I determined vegetable crops need about 1 inch of water per week in Bozeman, Montana, in April and early May. This requirement increases to about 11/2 inches per week in late May and early June, 2 inches per week from mid-June to early July, and 2–21/2 inches per week from mid-July to mid-August. Water needs decrease later in the season from about 11/2 inches in mid-August to early September, then about 1 inch of water per week through the first frost. These figures are highly variable according to location, with areas in eastern Montana requiring up to 3 inches of water per week in the heat of summer. Use pan evaporation figures from your local weather bureau or set up a test in your garden to determine how much water you really must apply to replace that used by your garden plants.

Here's how: Place a wide-surfaced container, such as a 9 x 13-inch cake pan, in the garden exposed to full sunlight. With indelible marker make tick marks at 1-inch intervals down the inside wall of the container, and then fill it with water so that the waterline rests on a mark. Check the water level after 1 week. If the level has gone down to the next lower mark, then evaporation loss for that week was about 1 inch. Pan evaporation fairly closely mimics water use by your plants, so you should apply about 1 inch of water (or whatever the loss was) to the garden to compensate.

What does 1 inch of water mean? It means enough water so that, if none of it drained away, it would make a puddle 1 inch deep. To apply 1 inch of water over 1,000 square feet requires about 623 gallons, which weighs about 5,200 pounds. Applying 2 inches of water over 1,000 square feet requires 1,246 gallons. That's a lot of water! High soil organic matter and the use of mulches increase water-holding capacity and substantially reduce the need for frequent watering.

How Much Is Enough?

There are a couple of ways to determine if you are applying sufficient water. You can measure how much water your outside spigot puts out in 1 minute. The one at my house puts out about 10

gallons per minute. Therefore it will take a little over 1 hour to apply 1 inch of water to 1,000 square feet (60 minutes x 10 gallons = 600 gallons, or nearly enough to cover 1,000 square feet with 1 inch of water). Another way is to place empty tuna fish cans about the garden beneath overhead sprinklers or soaker hoses, and when they are full of water, you have applied about 1 inch. Since overhead sprinklers do not distribute water evenly over the soil surface, place those cans at various distances from the sprinkler head.

The easiest way to determine if you have watered enough is to squeeze a little soil in your hand. If it will not form a ball it is too dry; if it forms a ball that will not crumble with a firm touch it is too wet. If it forms a loose ball that breaks with the slightest touch, then you are probably okay. Dig a hole in the garden and feel the soil on its sides. Moist soil feels cool. If the soil is moist to a depth of a couple of feet, you have watered enough. Your garden is in trouble if the soil is not damp to that depth. In fact, shallow-rooted crops such as cabbage, which have most of their roots in the upper 18–24 inches of soil, suffer if the top inch or two of soil is bone dry.

Critical Watering Stages

Vegetable	Growth Stage When Watering Is Critical
All crops, particularly summer and fall plantings	Germination
Asparagus	Fern development
Beans, peas	Flowering, development of pods
Beets, carrots, radishes, rutabagas, turnips	Root enlargement
Broccoli, cabbage, cauliflower, lettuce	Head development
Cucumbers, eggplant, melons, peppers, squash, tomatoes	Flowering, fruit set and development
Garlic, onions	Bulb enlargement
Potatoes	Tuber enlargement
Sweet corn	Tasseling and ear development

(Source: Adapted from Splittstoesser 1979.)

Plants experiencing incipient wilt need water immediately.

When to Water

When your plants wilt in the heat of day and recover at night, they are at the stage of incipient wilt— *water immediately*. Waiting even a few days may place them in a permanent wilt condition. Even after plants suffering from incipient wilt recover, yield may be reduced by as much as 30 percent. Water is more critical during certain stages of plant growth. Be sure to supply enough water when your crop is beginning to form a plant and when the portion you are interested in eating is developing.

How to Water

Water newly seeded beds lightly but frequently. There's no need to water deeply when there are no roots. Don't just sprinkle established crops. When you water established crops, water deeply so the upper foot or two of soil is dampened. This promotes deeper root development. In other words, water more deeply as the crop

root systems grow more deeply into the soil. The more deeply you water, the less frequently you will have to water. Water when the temperature is rising and the air is calm; from 7 to 9 a.m. is a good time. Too much water evaporates or is blown away from the plants when applied during midday. Overhead sprinklers are popular but waste water; it's better to use soaker hoses that apply water directly to the soil. You don't water the weeds when you use soaker hoses! Always water the soil, not the plants' foliage. Very little to no water is absorbed through the leaves; water placed there only evaporates.

Watering is easy. Whether you choose a soaker hose, impact sprinkler, or hand watering, be sure it gets done, and with the right amount. If you go on vacation, leaving the watering to your adorable 10-year-old neighbor when the heads on the broccoli or ears on the corn are developing is probably not a good idea.

Chapter 10

Weeds, Problems, and Pests: Fighting the Good Fight

Gardens, weeds, problems, and pests go hand in hand in hand, so get used to it! Controls involve a variety of options, but good gardeners always begin with the least toxic as their first line of defense. You don't always need to work down the list to a pesticide, but its use is an option. Let's start with weeds.

Weeds

How to define a weed? Ah, let me count the ways. A weed is simply a plant out of place. Volunteer tomatoes in your cabbage patch are weeds. Like prickly lettuce, a weed may be unsightly; like purslane, tough to control; or like red-root pigweed, tall and gangly, shading other plants. Most are vigorous and difficult to control, harbor insects and diseases, and compete with our vegetable plants for sunlight, water, and nutrients. That's why we call them weeds. They have no place in the garden and you will have to control them, one way or another, before they go to seed. Just one plant of common purslane can produce more than 100,000 seeds, which can remain viable in the soil for 20 years. Seeds of black mustard remain viable for more than 40 years. So, let one weed go to seed and you compound your problems manyfold.

One way to help keep the garden weed-free is to watch what you put into it. Fresh manure, particularly horse manure, will be infested with weed seeds. Be sure all manure is composted or well-rotted before you put it into the garden. Do not substitute hay for clean straw (for any reason) as hay may contain seed heads of weeds and grass. If you do have weeds that have gone to seed before you could pull them, don't compost them or turn them under but get them out of the garden altogether.

Rototilling the garden in autumn can bury some weed seeds, preventing them from germinating, while uncovering others that will be exposed to winter conditions and hopefully killed outright. Oregon studies have suggested that tilling at night discourages some weed seeds from germinating. Summer annuals such as lambsquarter and pigweed are most affected by night tillage. Try it on a moonlit night and see if it works for you. A fall cover crop can smother winter annual weeds and will serve as a great green manure crop when turned under in spring.

Summer cover crops such as buckwheat help smother weeds as well as add organic matter to the soil.

You don't need fancy equipment to take care of weeds, although you may enjoy selecting one of the more interesting hoes that are available in catalogs. My favorite is called a "collinear hoe," which is essentially a narrow 5-inch single-edge razor blade, kept razor sharp with each use. Cultivating with a sharpened hoe destroys most weeds. Hoes should be used with a scraping motion, not a chopping motion. You only have to scrape the soil surface to sever the weed stems. Disturbing the soil as little as 2 inches deep can destroy the surface feeder roots of your vegetable plants. Hoeing not only destroys weeds, but it conserves soil moisture, decreases surface-water runoff, and slows the upward migration of moisture from lower soil levels. Cultivate as soon as you see weeds emerge, preferably when the soil is dry; cultivating wet soil ruins its structure and can cause compaction. If you wait until the weeds are grown, you will be tempted to pull them. Don't! Tall weeds have roots that are intertwined with those of nearby vegetables, and pulling them could damage the vegetables' root systems. If the tall weed is too tough to sever with a hoe, cut it off with pruning shears and leave the roots in place until the vegetables are harvested.

We often see ads where a smiling gardener is using a rototiller for cultivating between the rows of vegetables. This is probably a

bad idea. Doing so destroys surface roots and most feeder roots between the rows, truncating the plant's root system, which severely and negatively affects its ability to forage for water and nutrients. Use the rototiller only for tilling the garden before planting.

Much about Mulches

Mulching conserves soil moisture by up to 50 percent compared to bare soil, keeps ripening fruit off the ground, and reduces rotting. Mulches may cool or warm the soil, depending upon the type of mulch; add organic matter when turned under; and prevent weed seeds from germinating. Before applying a mulch, remove all weeds and moisten the soil.

Organic mulches cool the soil and delay its warming in spring. For that reason they should not be applied until early summer when soil has warmed sufficiently for rapid root growth. Apply about 6 inches of organic mulch for the best weed control. As the lower layers of mulch begin to rot, vegetable roots grow into them, establishing a dense network of feeder roots to better forage for water and nutrients. Soil microbes do use some nitrogen to break down the organic mulch, so add about 2 pounds of 5-10-10 or its equivalent per 100 square feet of mulched area. Like all mulches, organic mulches moderate soil temperature, conserve soil moisture, and suppress some weed growth. However, most organic mulches will not adequately control grasses, perennial weeds, and established annual weeds.

Clean straw makes a good mulch and keeps the soil cool and moist. I think soft oat straw makes a better mulch than the stiffer rye or wheat straw. Barley straw is good, and its barbs prevent the wind from moving it around. You will need about a ton of straw to mulch a 1,000-square-foot garden. Weed-free legume hay breaks down rapidly, requires no additional nitrogen, and is particularly good for use on slow-growing crops such as peppers because it releases its nutrients fairly rapidly. Chopped leaves make a great mulch, though some weeds will find their way through them. An easy way to chop leaves is to run over them with a lawn mower, if you have no chipper shredder. Grass clippings from lawns where no herbicides have been applied work well, though be sure to let them dry for a day before you put them on the garden; wet clippings can

mat, ferment, and damage young seedlings. Compost and well-rotted manure make great mulches, too, as does peat moss. Unfortunately, peat moss is pretty expensive, can be blown about by wind, and may crust over, preventing water from penetrating into the root zone. To prevent this, mix the peat moss with other materials such as leaves or straw. Shredded newspapers soaked in water also make a satisfactory mulch. Like peat moss, however, these also can crust over, so it's better to mix them with straw before applying. Cardboard sheets work well in walkways. Wood chips and sawdust have no place as mulch in the vegetable garden; because both are high in carbon, microbes require a lot of nitrogen to break them down. In every case where I've seen sawdust used as mulch in a vegetable garden, the vegetables have suffered from severe nitrogen deficiency.

Inorganic mulches, particularly the plastics, are becoming more popular. Plastic mulches come in sheets of various colors and widths and continue to be a topic of research. (Check online at extension.psu.edu/plants/plasticulture for results of cutting-edge research.) They warm or cool the soil, depending upon their color; are weed-free; reduce fluctuations in soil temperatures; increase earliness and total yields, particularly in warm-season crops; and prevent some grasses and other difficult-to-manage weeds from emerging. They are light-weight, inexpensive, and easy to apply. Plastic mulch can be used between rows of crops such as beets and carrots; or transplants such as cabbage and tomatoes can be set in holes cut through the mulch. Their downside is that they add no organic matter to the soil and normally must be removed at the end of each growing season.

Three mil (0.003 inch thick) or 1.5 mil (0.0015 inch thick) sheets of black polyethylene block sunlight to prevent weed seeds from germinating. Most references also state that it warms the soil. In our Bozeman trials we found that it does not warm the soil substantially but rather warms the air trapped between the soil surface and the underside of the mulch. By conserving soil moisture and preventing weed growth, the black plastic promotes strong root growth, which in turn can lead to vegetables maturing earlier than vegetables planted in bare soil.

Plastic mulches of other colors are widely available. Perhaps the most noteworthy of these are the red plastic mulches. Like the black plastic mulches, these conserve soil moisture. Unlike the black

plastic, they warm the soil and strongly promote growth and maturity of some plants, particularly tomatoes and peppers. In contrast to black plastic, they do not totally prevent weed growth; some weeds germinate beneath them but their growth is etiolated (spindly) and weak, preventing them from causing major interference with growth of your vegetables.

Clear plastic mulch warms the soil up to 8–10°F more than most other plastic mulches and is preferred for use on heat-loving crops such as melons and on early plantings of cucumbers, peppers, tomatoes, squashes, and sweet corn. The clear plastic can hasten harvest by a week or so and leads to higher yields. Unfortunately, clear plastic allows weed seeds to germinate and can lead to sometimes heavy weed growth beneath the plastic. Be sure that the temperature beneath the clear plastic does not go above 90°F during bright summer days.

Other inorganic mulches include white plastic, which may repel some insects but has little effect on soil temperature. Aluminum foil used as a mulch will repel some insects such as aphids but it also keeps the soil up to 10°F cooler than bare soil. With our short growing season, this is probably not a good option.

New mulches are constantly being released, including photodegradable and wavelength-selective products. Visit your local garden center to see what's new.

More Weapons in the Fight against Weeds

The technique known as “flaming” uses the flame of a propane burner to destroy annual weeds. To be most effective, weeds must be young with fewer than two true leaves, so it’s typically first done after preparing the garden but before vegetable seeding occurs. The flame destroys the growing point of the weed, essentially killing the aboveground portions of the plant. More mature weeds may need several flaming episodes before control is effective. Grasses are more difficult to control with flaming because their growing point is below the soil surface. As mentioned, flaming destroys only the aboveground portion of the weed but leaves the roots uninjured. Some plants therefore may resprout, and additional flaming may be in order. Some weeds are strongly resistant to flaming. Flaming is usually ineffective on perennial weeds.

Some vegetable plants produce so much foliage that they shade the soil around them, minimizing germination and growth of many weeds. The cucurbits, beans, corn, potatoes, and tomatoes are effective shade crops. Plants that produce little foliage, such as carrots and onions, are not. Keep your soil weed-free early in the

season and the crop foliage will keep it mostly free from weeds later.

Herbicides kill plants. Nonselective herbicides kill all plants, so take care to apply them correctly, and *read the label.* Most herbicides have no place in the home vegetable garden; however, some organically acceptable herbicides show promise as being safe and effective for home use. These include some soap-based products and some essential oils. Research has shown that both clove oil and cinnamon oil at concentrations between 1 and 5 percent in water effectively controlled some small grass plants. All of these herbicides kill only the tissue they contact, so it is important to achieve good coverage; use of a surfactant (such as dishwashing soap) is highly recommended. Because they have no residual effect, they will have to be applied repeatedly as weeds emerge.

If these products do not provide you with effective control and you are sore from hoeing, you may have to resort to an herbicide like glyphosate, especially for control of tough weeds such as quack grass. This product is commonly sold under several trade names, including Roundup. It is nonselective and thus will kill any green tissue to which it is applied. Follow all label directions and use with care. Pay attention to research that is ongoing regarding use in food crops.

Another herbicide that is widely used by homeowners is trifluralin, sold under names such as Treflan. This product must be applied before weed seeds germinate. It gives effective control of grasses and some broadleaf weeds by inhibiting cell division in shoots and roots of seedlings. The active compound is strongly adsorbed by soil particles, particularly soil organic matter, and has a field half-life of about 45 days, during which time it is slowly degraded by soil microbes and by sunlight. It has a very low toxicity and poses little threat to humans when used according to label directions.

Read all label instructions when using any pesticide, and be sure to follow them carefully, wearing all of the necessary protective clothing and using equipment as directed. Yes, it’s that important.

Water can be used as a weed management tool. Weeds need water to grow, so effective water management may help suppress them. Sub-surface irrigation with a buried soaker hose will minimize the amount of surface moisture available to weeds.

Geese will graze weeds. They prefer grasses but will eat other

weeds when grass populations are depleted. Don't place geese in corn (a grass) or in tomatoes. You will have to remove the geese as the crops mature and also provide water, shade, and protection from dogs and other predators. All in all, geese may be more trouble than they are worth in weeding the garden.

Common Problems Seen in the Vegetable Garden

Vegetables may be damaged by various pests, including insects and disease, but damage also may be caused by the environment, inadequate or excessive levels of nutrients, and soil issues. Here are some common problems, their possible causes, and what you can do about it.

Controls for Common Problems

Symptom	Possible Cause	Possible Control
Wilt	Lack of water	Water
	Excess water	Stop watering
	Disease	Use resistant varieties; crop rotation; fungicide sprays
	Damage to stem or roots	Protect next time; control insects
Spots on leaves and stems	Fertilizer burn	Follow label directions
	Pesticide burn	Follow label directions
	Disease	Use resistant varieties; fungicide sprays; crop rotation
	Nutrient deficiency	Determine deficiency and correct
Weak growth	Shade	Eliminate shade
	Excess water	Stop watering; improve drainage
	Crowding	Thin
	Excess N	Reduce fertilizer
	Disease	Use resistant varieties; crop rotation; fungicide sprays
	Root damage	Determine source and correct
Leaf curl	Wilt	Use resistant varieties; rotate crops; remove diseased plant
	Virus	Remove diseased plant; control insects
	Aphids	Control insects
Leaf roll	Drought	Water
	Virus	Remove diseased plant; use resistant varieties
Stunted growth; yellow foliage	Insufficient water	Water
	Excess water	Don't water
	Poor drainage	Improve drainage
	Improper soil pH	Correct soil pH
	Compacted soil	Amend soil
	Insufficient fertility	Fertilize
	Disease	Use resistant varieties; remove diseased plants; apply fungicide
	Virus	Use resistant varieties; remove diseased plants
	Nutrient imbalance	Correct imbalance

Symptom	Possible Cause	Possible Control
Poor germination	Insufficient time Too hot; cold Too wet; dry Bird damage Seed maggots Old seeds	Wait Wait Adjust watering Control birds; wait Use treated seeds Use viable seeds
Young plants die	Damping off Fertilizer burn	Use a fungicide; sprinkle sand over seeded row Follow label directions
Leaves have holes	Slugs Insects Hail	Trap Use insecticide; handpick Row cover protection
Leaves dried out	Wind damage Mildew	Construct or grow windbreak Use fungicide next time; increase air circulation
Twisted; deformed growth	Herbicide damage Virus Nutrient deficiency	Follow directions on the label; don't use herbicide-treated lawn clippings; examine source of manure for herbicide contamination Remove diseased plant Correct deficiency
Fruit blossom ends rot on eggplant, tomato, pepper, and squash	Improper soil pH Insufficient calcium Compact soil Root damage Soil water imbalance Fruit rot	Correct – See chapter 8 Add calcium to soil; calcium nitrate sprays Amend – See chapter 8 Be careful next time Mulch; apply water evenly and consistently Use fungicide; remove affected fruit
Poor fruit set	Too cold; too hot Excess N Poor pollination Immature plants	Wait Follow directions Insufficient bees; weather too hot, too cold, or too windy Wait

First Line of Defense

In the garden, weeds and pests can work together to inflict damage on your crops, so if you can gain the upper hand with one, you'll have the advantage in battling the other. A first line of defense against weeds and pests is to locate your garden in an area that has

good air circulation and is in full sunlight. Well-drained soil is critical; poorly drained soil promotes seed rots, damping-off, and restricted root systems leading to weakened plants. Water only in the morning, as wet foliage at night may increase the incident of mildew.

Keep the garden and surrounding area clean and neat. Compost, turn under, burn, or otherwise dispose of plant debris right after harvest. Do not compost diseased plant material; any material infected with the soilborne pathogens *Verticillium* and *Fusarium* should be removed from the property and never turned under or composted. Keep the garden weed-free. Weeds compete with your vegetables for water and are hosts for diseases and insects. For example, lambsquarter harbors leaf miners, which ruin spinach, beet greens, and Swiss chard, and pokeweed is a host for tobacco mosaic virus, which attacks tomatoes, potatoes, and peppers. Do not allow smokers or tobacco chewers into the garden, for their tobacco products can also carry the tobacco mosaic virus. Lastly, do not walk through the garden when it is wet. You may brush against a diseased leaf, picking up fungal spores, and then spread the pathogen to a healthy leaf.

Not all pests are present in all locations. When in doubt contact your local county extension office to find out which ones to watch for. The table on page 119 lists some damage you may see in the garden, the insect possibly causing the damage, and the plants attacked. Use this table to identify what insect you are up against.

Plant only disease-free seeds and transplants. Fungicide-treated seeds are helpful in warding off rots, especially in cold, wet soils. Some *Brassica* seeds are pretreated with hot water to control some seed-borne diseases. Catalogs may note whether the seeds have been treated with hot water, but seed packets generally do not. Using onion sets will avoid onion smut, which attacks only onion seedlings.

Three- or four-year crop rotations are very effective in controlling soilborne diseases. For example, clubroot, a disease that attacks brassicas, and root knot nematode, which attacks many plants, remain viable in soil for up to 3 years, so a 4-year rotation will go a long way toward managing these problems. Unfortunately, some diseases, such as onion smut and potato scab, remain viable in the soil for many years and cannot be controlled effectively solely with crop rotation. Root maggots, grubs, and wireworms are

especially attracted to root vegetables and brassicas. If you have a lot of these insects in the garden, then plant beans, peas, Swiss chard, and spinach, which are vegetables that are not attacked by these insects.

Common Insect Pests and the Damage They Cause

Damage	Insect	Plants attacked
Many small green or black sucking insects, usually on the underside of the leaves; may cause leaf curl.	Aphid	Many
Young plants cut down at night at soil level	Cutworm	Beans, corn, tomato, pepper, eggplant, and *Brassica* transplants
Wedge-shaped insects that suck sap and hop when disturbed	Leafhoppers	Beans, lettuce
Chewed leaves, silvery trail of dried slime visible in the morning	Slugs	Plants with heavy foliage near the soil
Brown or white tunnels in leaves, small maggot in tunnels	Leaf miners	Beets, chard, spinach
Weak plants, maybe wilted, lateral roots absent	Cabbage maggots; onion maggots	Brassicas, onions
Holes in leaves eaten by inch-long green worms	Cabbage worm; cabbage looper	Brassicas
Numerous pinholes in leaves	Flea beetles	Brassicas, eggplant, pepper, potato, tomato, kohlrabi, radish, kale
Silks cut at ear, large worm eats corn kernels	Corn earworm	Corn
Worms tunnel in corn ears and stalk	Corn borer	Corn
All parts of plant chewed	Cucumber beetles	Cucurbits
Plants defoliated by black-striped beetles or red-brown larvae	Colorado potato beetle	Potato, eggplant
Vines suddenly wilt, holes in stem near soil line	Squash vine borer	Squash
Leaves eaten by large green worm with reddish horn	Hornworm	Tomato

Fall plowing turns under debris and turns up insects that will later be winter-killed. Plant a cover crop after plowing and turn that under in spring.

Work *with* Mother Nature when possible by using trap crops

when necessary. Radishes attract wireworms away from carrots, and kale attracts harlequin cabbage bugs away from cabbage.

Second Line of Defense

In spite of all your hard work protecting your garden with the first line of defense, you may have to follow through with the second line. Use tar paper (or heavy cardboard) collars around transplants to control cutworms, being sure the collars extend about 1 inch below and 2 inches above the soil line, leaving no more than 1 inch between the plant stem and the collar. Tar-paper collars that lie flat on the ground and around the stems of young *Brassica* transplants will protect them from root maggots. Fit the stem through a slit in the collar. Finally, wood ashes, sharp mason's sand (not river sand), or diatomaceous earth sprinkled around the stem of young transplants reduces damage from slugs and cutworms.

Protect young plants from insects (and, to some degree, hail!) by positioning row covers over your garden rows immediately after planting.

Trap slugs with shallow bowls of stale beer or by placing a board between rows of vegetables. The slugs will drown in the beer, or take shelter under the board. You'll need to remove them manually.

Aluminum foil placed under the plant disorients aphids and reduces their feeding damage by reflecting sunlight onto the lower sides of the leaves, where aphids hide. Unfortunately, in our Rocky Mountain region, we get such abundant sunlight that the aluminum foil might reflect too much and damage the plant tissues.

A strong stream of water can knock some insects off plants. This is especially effective in controlling aphids and mites. Since the late 1700s some gardeners have sprayed warm, soapy water onto their plants. This is effective in controlling damage from some insects. You can buy prepared insecticidal soap; try it on a few plants first to be sure it does no damage. Do not spray in the heat of the day and never use detergents.

Encourage birds by planting fruit plants near the garden. Elderberry, crabapple, and highbush cranberry are good examples. Birds swoop from these onto the insects in the garden and do a nice job of cleaning up the area free of charge. (Robins, on the other hand, are notorious for pulling up seedlings!) Chickens and geese will do a great job eating not only insects but young weeds, as well. Garden snakes, toads, and bats all help to control garden insect populations.

Handpicking is inexpensive, easy, and perfectly alright for larger insects like hornworms, cabbage worms, and Colorado potato beetles. Pick these every day to keep populations and damage low. You can find hornworms clinging to the lower surfaces of the foliage in early morning. Pull them off and step on them. Place other insects into a can of cooking oil.

Third Line of Defense

Until now I've talked about defensive and very light offensive measures for controlling insects. But as pest populations increase, you may have to take more severe measures. Encouraging and even

introducing predators and parasites into your garden is the third line of defense. Predators are larger than the insects they control and are not diet conscious, eating “good” as well as “bad” insects. Nor do they have any allegiance to the gardener, for as soon as their food supply is gone, so are they. Also, introducing these in a windy area is probably a waste of money.

The table below provides an overview of some predators and their food preferences, along with parasitic wasps that lay their eggs inside or on their target. You’ll notice praying mantises are not among them, since these insects are not particularly effective in controlling vegetable-garden pests. Their preferred food sources are bees, wasps, flies, grasshoppers, and crickets. Except for grasshoppers, these insects are not really destructive to the garden. Further, mantises sit and wait for their prey. They hatch in late summer after most of the damage has been done, and the first to hatch eat those that hatch subsequently, so many are destroyed quickly.

Beneficial Insects and Their Targets

Predator	Target
Lacewing (ant lion)	Aphids, mealybugs, scale, spider mites, insect eggs, other small insects
Ladybugs	Aphids, insect eggs, scale, mites
Pirate bug	Aphids, small insects, mites
Damsel bug	Aphids, caterpillars, leafhoppers, mites
Syrphid flies	Aphids
Ichneumon wasps	Cutworms, caterpillars
Tachinid flies	Cutworms, caterpillars, some beetles
Chalcid wasp	Imported cabbage worm
Braconid wasp	Caterpillars, beetles
Aphidius wasp	Aphids

Aphids are parasitized by the *Aphidius* wasp, which leaves an exit hole in the bloated aphid mummy when it emerges.

Some pathogens control insects when used according to directions. One very effective group of pathogens is *Bacillus thuringiensis* (Bt), sold under such trade names as DiPel and Thuricide. There are several strains of this *Bacillus* available for use, depending on the target pest. Be sure you use the correct strain for the insect damaging your crop. These bacterial pathogens attack over 400 species of caterpillars but leave other insects and animals unharmed as they are eaten by the target pest. They are very safe for the home garden.

Fourth Line of Defense

In most years these first three defenses will hold the line against total destruction of your garden. But sometimes they fail, and you may have to go to your fourth—and last—line of defense. Give up or use a pesticide. The word *pesticide* unjustly invokes fear into the hearts of some gardeners, but it shouldn't. A pesticide is a substance that kills pests, so *you* were a pesticide when you stepped on that slug. Soap and water are pesticides, and so is *Bacillus thuringiensis*. I'm often asked to recommend nontoxic pesticides. That is an oxymoron since, by definition, a pesticide kills a pest, therefore it is

toxic and lethal. Like medicines, pesticides have their effective use, but misused they can have unfortunate effects, such as killing beneficial as well as nonbeneficial insects. Also like medicines, there are relatively innocuous, less toxic pesticides, and there are stronger, more toxic pesticides. There are pesticides that are effective on some insects and diseases but ineffective on others. Lastly, like medicines, you can choose to use them or not.

Toxicity of Some Common Pesticides and Household Products for Comparison

Note: LD_{50} values vary slightly among different data sets.

Substance	Acute, oral LD_{50} (mg/kg body weight)	Amount ingested by a 150 lb. person to meet the LD_{50}	Notes
Gasoline	150	A few drops to 1 tsp.	
Rotenone	130–1,500	1 tsp. to 1 oz.	Common botanical insecticide; “Warning” may be on the label.
Caffeine	200	1 tsp. to 1 oz.	
Carbaryl	500	1 tsp. to 1 oz.	Low mammalian toxicity but highly toxic to bees—do not apply to blooming crops or when bees are actively foraging in the area; “Caution” on the label
Malathion	1,200	Over 1 oz. to 1 pt. or 1 lb.	Highly toxic to bees—do not apply to blooming crops or when bees are actively foraging in the area; “Caution” on the label
Sabadilla	1,200	Over 1 oz. to 1 pt. or 1 lb.	Botanical insecticide
Aspirin	1,300	Over 1 oz. to 1 pt. or 1 lb.	

Substance	Acute, oral LD_{50} (mg/kg body weight)	Amount ingested by a 150 lb. person to meet the LD_{50}	Notes
Pyrethrum	1,500	Over 1 oz. to 1 pt. or 1 lb.	Common botanical insecticide; no warning word on the label
Table salt	3,300	Over 1 oz. to 1 pt. or 1 lb.	
Glyphosate	4,300	Over 1 oz. to 1 pt. or 1 lb.	Active ingredient in Roundup and other nonselective herbicides; no warning word on the label
Sulfur	>5,000	Over 1 lb. or 1 pt.	All natural fungicide; can be phytotoxic; no warning word on the label
Captan	9,000	Over 1 lb. or 1 pt.	Common fungicide; no warning word on the label
Treflan	>10,000	Over 1 lb. or 1 pt.	Common ingredient in some preemergent herbicides; no warning word on the label.
Insecticidal soap	16,900	Over 1 lb. or 1 pt.	No warning word on the label
Bt	Essentially non-toxic to nontarget organisms	Over 1 lb. or 1 pt.	No warning word on the label
Copper, fixed	Essentially non-toxic to nontarget organisms	Over 1 lb. or 1 pt.	Fungicide; no warning word on the label

Just as there are many types of pests, there are many types of pesticides. Insecticides kill insects, fungicides kill fungal pathogens, rodenticides kill mice and rats, miticides kill mites (which are not

insects), and herbicides kill plants.

We can gauge the relative toxicity of a substance by referring to its LD_{50}. This is the amount of the substance needed to kill 50 percent of the test population and is expressed in mg/kg of body weight. The LD_{50} is also given as "oral" or "dermal" (that is, administered by mouth or through the skin), and as "acute" or "chronic." Rats are often used as test animals for oral values, and rabbits for dermal values. We commonly discuss toxicity in terms of an acute, oral dose. The *smaller* the LD_{50}, the more poisonous the compound. The table on pages 124–25 presents information on some pesticides commonly used in the home garden, along with the toxicity of some common household products for comparison.

A word of caution regarding oversimplification: Simply because a compound has a high acute oral LD_{50} does *not* mean it is harmless. Carbaryl is a good example of a compound that has a relatively low mammalian toxicity but is highly toxic to some nontarget organisms such as bees. Also, do not be fooled into thinking that a pesticide made from plants (botanical) is "naturally" safe. Far from it. Rotenone, made from either the cubé root of South America or the derris root of Africa, is fairly toxic to mammals and highly toxic to fish. Pyrethrum, made from the dried and ground flowers of tropical chrysanthemum, is about as toxic to humans as malathion.

Pesticides are tools, no more or less dangerous than the person using them. Before you use them stop and think: "Is the damage being done to the garden sufficient to warrant their use? Can I control the damage in another way, perhaps by handpicking or a water spray?" If the answer to the first question is "yes" and the answer to the second "no," then consider using the least toxic pesticide that will do the job.

Read all labels carefully and follow all directions. Here are a few points to consider:

1. For pesticides labeled "Caution," wear—at the least—long pants, a long-sleeved shirt, socks, and shoes. For those labeled "Warning," add chemical-resistant gloves to your outfit. Pesticides labeled "Dangerous" should not be used in the home garden.
2. Mix according to the label directions. Wettable powders (W or WP) and emulsifiable concentrate (E or EC) formulations must

be mixed with water before application. Follow recommended concentrations carefully. If 2 tablespoons of the wettable powder are recommended to be mixed with 1 gallon of water, don't use 4 tablespoons, thinking that the mix will be more effective. It won't be; you will waste your money and put more of the compound into your garden than necessary.

3. When honeybees may be present, apply in late afternoon, night, or early morning when they are not actively foraging. Evening is generally safest.
4. Do not spray on a windy day. Spraying in early morning is often the best time. Spraying in the heat of the day can cause phytotoxicity with some plant/pesticide combinations. Cucurbits are particularly sensitive to applications of carbaryl when temperatures are above 80°F.
5. Direct the pesticide at the target plant, being sure to treat both the upper and lower sides of the leaves.
6. Clean sprayers and clothes thoroughly after use, following directions on the pesticide label.
7. Store all pesticides in a locked cabinet out of reach of children and pets.
8. Dispose of empty containers as directed on the label.

Most new gardens should have very few pests, and it's likely you won't need to use any pesticides. After a few years some pests may find your garden, but you won't have all of them that are discussed here. If you need any help at all, begin with the least toxic controls, handpick slugs, and blast aphids with water. Weeds are often the worst pests of the garden, and, if left uncontrolled, they will take over the area in short order. Weeds are thieves: They rob plants of water, nutrients, and sunlight, and rob you of good harvests. Stay on it. Evict them from your garden as soon as you notice them. Pest control is not that difficult; just manage those insects and weeds one at a time.

The following table lists pests and diseases often found on certain vegetables with some suggested controls. This list is not intended to be conclusive, and it is accurate as of the date of this publication. Rules and regulations governing pesticide use change constantly. Always check latest recommendations before using any pesticide and *read the label*. It will tell you if the product is effective on the plant with problems and on the pest you want to control.

Some Vegetable Pests and Diseases and Some Controls

Crop	Pest	Description	Control
Asparagus	Rust	Red-black pustules on foliage and stem	Burn diseased material; plant resistant varieties
	Asparagus beetle	Metallic blue-black adults with yellow wing markings and slate-gray larvae feed on shoots and foliage	Carbaryl, rotenone, malathion; handpick
Bean	Anthracnose	Dark sunken spots with pink centers on pods; deep red to black cankers on stems	Use disease-free seeds in a 2- or 3-year rotation and do not cultivate wet beans; sanitation
	Bacterial blight	Large brown spots encircled with yellow on leaves; watery spots on pods	Use disease-free seeds in a 3-year rotation and do not cultivate wet beans
	Powdery mildew	Very faintly colored spots appear on leaves, eventually turning white and powdery	Sulfur
	White mold	Water-soaked spots on the plant; white cottony mold on pods	Use approved fungicides
	Aphid	Very small green, black, or pink soft-bodied insect that sucks sap from the plant and may transmit diseases	Wash plants with a strong water spray; insecticidal soap
	Leafhopper	Green, soft-bodied, wedge-shaped insect that sucks the sap and causes plant distortion	Carbaryl or handpick
	Mexican bean beetle	Yellow-red beetle with 16 black spots on its back and its orange spiny larvae eat leaves	Carbaryl, malathion, or handpick
	Tarnished plant bug	Brown, oval, flat bugs with a triangle marking at their rear suck plant sap	Handpick

Crop	Pest	Description	Control
Beets	Cercospora	Light brown spots with deep red borders on leaves	3-year or longer rotation
	Leaf miner	Yellowish maggot-like larvae tunnel between the upper and lower surfaces of the leaves, causing white, papery tunnels	Eradicate weeds, especially lambsquarter; trim infested leaves before eating; destroy badly invested leaves; malathion; row covers
Brassicas (broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, kohlrabi)	Black leg	Girdling of stems at soil line; gray spots speckled with black dots on stems	Sanitation and long rotation; use hot-water-treated seeds
	Club root	Leaves that flag on hot days; yellow leaves; large irregular swellings on roots	Maintain soil at pH 7.2 or slightly higher; use disease-free seeds
	Fusarium yellows	Yellow-green leaves, lower leaves drop, plants stunted	Use yellows-resistant varieties
	Flea beetle	Very small, dark beetles, mostly early in the season, make numerous pinholes in leaves during feeding	Carbaryl
	Cabbage maggot	Yellowish maggot tunnels into lower stem and roots	Use tar-paper swatches over the soil and around the base of the stem
	Cabbage looper	Green worms 1½" long with thin white lines; worms "loop" as they crawl	Carbaryl; malathion; DiPel
	Imported cabbage worm	Thin, velvety green worms 1¼" long emerge from egg masses on the undersides of the leaves and eat holes in the head and foliage	See cabbage looper

Crop	Pest	Description	Control
Carrot	Aster yellows	Bushy purple tops with yellow young leaves; roots become woody and "hairy"	Control leafhoppers, which carry the pathogen
	Leafhopper	See Beans	See Beans
	Rust fly	Yellow-white maggots tunnel into roots	Long rotation
Celery	Aster yellows	Yellow leaves; brittle and bitter petioles; plants stunted	Use resistant varieties; control leafhoppers and weeds
	Bacterial blight	Bright yellow spots appear on the leaves; center of the spots turn brown	Sanitation; copper compounds
	Aphid	See Beans	See Beans
	Loopers and other worms	See Brassicas	See Brassicas
Cucurbits (cucumbers, melons, squash, pumpkins)	Anthracnose	Red-black leaf spots; brown cankers on stems; oozing sunken spots on fruit	Use resistant varieties in 3- or 4-year rotations
	Bacterial wilt	Vines wilt and die; stem sap produces strings	Sanitation; control stripped cucumber beetles
	Powdery mildew	White, powdery film on leaves; foliage wilts	Use resistant varieties
	Aphid	See Beans	See Beans
	Cucumber beetle	Yellow beetle with 12 black spots on back or with 3 black lines on back; transmits bacterial wilt	Carbaryl; rotenone; handpick
	Squash bug	Flat, brown stinkbug	Carbaryl; handpick with rubber gloves
	Squash vine borer	White caterpillars bore into stem close to where it exits the soil; vines wilt	Slice stem lengthwise through the hole with razor blade

Crop	Pest	Description	Control
Eggplant	Aphid	See Beans	See Beans
	Colorado potato beetle	Oval beetle with 10 black and 10 yellow stripes that lays yellow eggs beneath the leaves; larvae have black spots; both stages destroy leaves	Handpick; regional differences have been noted in the susceptibility of certain strains to Carbaryl
	Flea beetles	See Brassicas	See Brassicas
Endive and lettuce	Tipburn	Edges of leaves brown and die	Prevent stress; use resistant varieties
	Aphid	See Beans	See Beans
	Flea beetle	See Brassicas	See Brassicas
	Loopers	See Brassicas	See Brassicas
Onion	Neck rot	Soft brown tissue at neck	Be sure bulbs are cured and dry before storage
	Pink rot	Roots turn pink, shrivel, and die	Use resistant varieties; long rotations; plant disease-free stock
	Smut	Black leaf spots open to reveal black spores	Approved fungicides; long rotations
	Maggot	Small maggots bore into bulbs and stems	Long rotation
	Thrips	Very small (1⁄25"); suck sap from plant tissue causing white stippling and brown leaf tips	Long rotation; soap spray; rotenone
Parsnip	Canker	Brown tissue at shoulder or crown	Mound soil over shoulders
	Carrot rust fly	See Carrot	See Carrot

Crop	Pest	Description	Control
Pea	Powdery mildew	White powdery mold on leaves and stems	Use resistant varieties; sulfur
	Wilt	Wilting, yellow leaves, stunted growth	Use resistant varieties; early planting; 3-year rotation
	Aphid	See Beans	See Beans
	Seed maggot	Maggots burrow into seeds	Long rotation
Pepper	Anthracnose	Dark, round spots with black specks on fruit	Use approved fungicide
	Aphid	See Beans	See Beans
	Flea beetles	See Brassicas	See Brassicas
Potato	Early blight	Dark brown leaf spots; reduced yields	Sanitation
	Late blight	Dead areas on leaves and stems; tubers rot in storage	Sanitation
	Scab	Rough scabby lesions on skin	Use resistant varieties; rotation; sulfur
	Aphid	See Beans	See Beans
	Colorado potato beetle	See Eggplant	See Eggplant
	Flea beetles	See Brassicas	See Brassicas
	Leafhoppers	See Beans	See Beans
Rhubarb	Crown rot	Petioles wilt; browning of the leaf base	Plant in well-drained soil; do not use heavy winter mulch
Rutabaga and Turnip	Club root	See Brassicas	See Brassicas
	Flea beetles	See Brassicas	See Brassicas
	Maggots	See Brassicas	See Brassicas
Spinach	Leaf miners	See Beets	See Beets

Crop	Pest	Description	Control
Sweet Corn	Seed rot	Seed rots in soil	Wait for soil to warm before planting; use treated seeds
	Smut	Large, smooth, white galls form on ears, tassels, and at nodes, breaking open to release greasy black spores	Control corn borer; use resistant varieties
	Earworms	Brown, green, or pink larvae feed on silk, kernels, and foliage	Carbaryl; daub silks where they emerge from husks with mineral oil just as they begin to brown
	European corn borer	Caterpillars feed on leaves then bore into the stalk up to the ear	DiPel; carbaryl; handpick worms before they enter the stalk
Tomato	Anthracnose	Sunken spots on fruit enlarge, their centers darken, fruit rots	Sanitation; rotation
	Blossom-end rot	Dark brown, leathery sunken spot appears at the blossom end of the fruit, enlarging to cover up to half of the entire fruit	Not pathogenic but a physiologic disorder specifically caused by a lack of calcium in the fruit; keep soil moisture constant; mulch plants
	Early blight	Dark brown spots on leaves; brown cankers on stem; girdling; leathery rotted areas on fruit near stem	Sanitation, rotation
	Fusarium	Yellowing and wilting of the entire plant	Use resistant varieties or long rotation
	Verticillium	Yellow areas on leaves turn brown; plants wilt at midday; leaves drop beginning at plant base	Use resistant varieties or long (7-year) rotation
	Aphid	See Beans	See Beans

Crop	Pest	Description	Control
Tomato (cont.)	Colorado potato beetle	See Eggplant	See Eggplant
	Flea beetle	See Brassicas	See Brassicas
	Hornworm	Large (3–4") green worm with white lines on its side and a distinct reddish horn at its rear	Carbaryl, DiPel, handpick

(Source: Adapted from Maynard and Hochmuth 2007.)

Chapter 11

Season Extenders: Cheating Time

We Rocky Mountain gardeners endure a host of challenges Mother Nature sends our way. And just when we think we've got all the challenges figured out, she throws us a curve ball. We deal with short growing seasons, of course, but in addition, we have cold night temperatures for much of the season, hail (expected and unexpected), drought, and wind. In other words, we typically can't waltz around the garden with new plants chanting, "Where'm I gonna put it?" like many lucky gardeners, oh no. We sleuth around our garden chanting, "How'm I gonna protect it?"

Those gardeners living at extreme elevations will find that even these season extension techniques are ineffective. While this book covers the Rocky Mountain region, intense measures, such as hoop houses or covered raised beds, must be taken by these challenged gardeners to produce vegetables successfully.

Cheating the Calendar

In our region good gardeners must take advantage of every means of lengthening short growing seasons. A difference of a few days can mean the difference between a bountiful harvest and no harvest at all. Season extenders smaller than greenhouses are meant to give you a few extra weeks of season, not months. You cannot plant tomatoes in your garden in Montana in January and expect them to make it with individual plant protection. Remember that all plants grown beneath plant protectors become tender and may be injured by sun and wind when the protectors are suddenly removed. Therefore, remove them gradually as plants become too large for them.

Individual plant or row covers used early in the season can allow you a few days' head start by moderating cold nighttime temperatures. **Hot caps** are small, inexpensive cones made of waxed paper and placed over individual transplants, held down with a rim filled with soil. They are meant to be used for one season only and in non-windy locations. Cut a slit in the top for ventilation.

Water jackets (top) and hot caps (bottom) protect individual plants from cold nighttime temperatures.

Water jackets resemble double-walled corrugated plastic cones and come in clear, red, and green varieties. Filled with water and placed over a transplant, these jackets moderate nighttime temperatures and provide good protection from cold and wind. They will not protect plants from deep cold but can provide pretty good protection down to temperatures in the low 20s°F, if the water doesn't freeze, depending upon the species of plant.

Homemade plant protectors include gallon milk and kitty-litter jugs with bottoms and caps removed, and even an upside-down 5-gallon plastic bucket with half the bottom removed for ventilation. Old tires placed around transplants afford some protection against wind and cold as the tires heat up the air surrounding the plant.

Unfortunately they can become mosquito nurseries later in the season.

If you live in a hail-prone location, wire or polyvinyl chloride (PVC) pipe hoops can be placed in the garden to support 1/4-inch-mesh hail screens during the hail season. These are set along the row at about 4- to 6-foot intervals. Row covers look like miniature greenhouses and are made from clear plastic, woven or spunbonded material, and other sheets. These sheets are placed over the same wire hoops used for hail screens, and their sides brought down into a soil trench on both sides of the hoops and buried. The ends of the tunnels can be left open for ventilation and the sides can be rolled up during nice weather. Tunnels promote early-season growth by increasing humidity and temperature around the plants while protecting them from wind and frost. Unfortunately, they are difficult to keep in place in windy locations. The same is true for spunbonded materials that are light enough to be placed directly on the plants. Called "floating row covers," these provide some frost protection but can damage your plants in a strong wind; they also can easily blow away if not anchored with rocks. Row covers also protect plants from some insects and should be placed over *Brassica* transplants immediately upon planting.

Protecting crops from a frost by covering with a blanket or sheet is more successful in the fall than in the spring as the covers trap ground heat stored through the summer; soils in spring have not yet begun to store ground heat, making this method less successful. Covering crops in fall may extend your season by several weeks if an Indian summer follows a light frost.

Cold frames and hotbeds were popular in previous generations for starting and hardening transplants and for growing a fall crop of spinach or lettuce. Depending upon the species of plants you grow and the severity of the season, you may be able to harvest fall-planted greens through early winter. Both types of frames are constructed similarly except that a hotbed is a cold frame with an internal source of heat. At one time the heat source was fermenting horse manure, but modern frames use thermostatically controlled electric heating cables or other sources. It is important to pay attention to the ventilation and temperature to be sure the interiors of the frames do not overheat.

A cold frame is a simple structure located so that the sashes (a fixed or flexible framework similar in appearance to a window or door) slope to the south. Common dimensions are for the north wall to be 12 inches in height above the soil line and the south wall 8 inches in height. These are located the length of the sash apart, usually 4–6 feet. Select rot-resistant wood for construction, or use copper naphthenate–treated lumber. Bank all sides with soil for insulation. The north side can be set against a building or into a bank for added protection. Old storm windows were once commonly used for sashes, but today you can make up sashes out of rigid or flexible plastic in any width and length you prefer. Be sure their frames fit the frame walls tightly. For added protection on cold nights, cover the sashes with blankets, sheets of rigid insulation, or straw, and be sure to provide very good ventilation during sunny spring days. Place a thermometer inside the frame to monitor temperature; if the air temperature rises above 85°F, ventilate by opening the top of the sash. Otherwise, purchase a device that will open and close the sash automatically to maintain proper temperature.

For more information on constructing hotbeds and cold frames, contact your local county extension office, or download the free MontGuide on the subject from the Yard & Garden section of the Montana State University (MSU) Extension Publications website (store.msuextension.org).

Did I mention drought? Rather than run your well dry watering the garden, collect any rainwater from your roof downspouts in a rain barrel, if not outlawed in your location. A small irrigation pump installed into your storage tank can provide your hose with water, or install a low spigot and let gravity do the work. Elevate

the barrel on bricks to allow room to connect the hose to the spigot. When running inside taps to warm the water, collect it and use it to water container plants.

As one of my MSU professors used to say, “Mother Nature winks at us all!” Wink back! Lengthen your short season, reduce the impact of drought, and protect your plants from hail! Don’t get mad, get even!

Chapter 12

Harvesting and Storing: Feeding Your Family

You've enjoyed working hard to take care of your vegetables all season, giving them the water, nutrition, and care they need. So don't goof up harvest and storage! Knowing when to harvest and how to store can be tricky for the novice, but with a little practice, you'll be able to enjoy the fruits of your labor all year.

What Is "Ripe?"

The best time to harvest a crop is not necessarily when the crop is ripe but rather when it has reached the stage for best eating. In fact, allowing some crops to ripen fully on the plant reduces yield and quality. For example, cucumbers are picked and eaten in an immature stage; allowing them to fully mature on the vine not only will give you big, mushy, yellow, inedible fruit, but the developing seeds of those fruit will signal the plant to stop producing flowers

and start ripening the seeds. The same is true for summer squash, beans, peas, and some other vegetables. So how do you tell when a crop is ready for harvest? See individual entries in The Vegetables section for specific instructions; here are some general guidelines.

Days to harvest. The number of days to harvest serves as a very general guide to determining when to harvest, though it may be off by a couple of weeks due to local weather and cultural conditions.

Physical characteristics. Examine your crop and look for the general characteristics shown in the chart below.

A yellow ground spot is one indicator of ripeness on a watermelon.

Ripeness. Most crops attain their peak eating quality (horticultural maturity) just before they attain full botanical maturity. Corn allowed to ripen fully on the stalk quickly passes its best eating stage (milk stage) and develops a tough skin around the kernels, finally drying into an ear with hard, starchy, humanly inedible seeds. Technically, it is at that end stage that the corn is "ripe," but by then it has long passed the best eating stage. Fully ripe summer squashes develop a tough rind and generally become unpalatable. Fully ripe peas and beans are dry, and their pods are ready to burst. This is the stage to harvest these crops for shell beans and shell peas to be used as baked beans or in pea soup. But snap beans and peas to be cooked and served (as usual) are harvested long before they are ripe, and before their sugars convert to starch. Leafy crops allowed to grow for too long get fibrous, off-color, and bitter tasting. So, harvesting at the right time is

paramount.

When to Harvest Based on Physical Characteristics

Characteristic	Crop
Full size	Most vegetables
External color	Most vegetables
Separates easily from the plant; good netting development; aromatic	Muskmelon
Compact head	Broccoli, cauliflower
Solidity	Cabbage, head lettuce, Brussels sprouts
Tenderness	Asparagus, corn, peas
Dry foliage	Garlic, horseradish, onion, potato, shallots
Internal structure (jellylike material forms around seeds)	Tomato
Milk stage	Corn
Orange or yellow ground spot; hard rind	Winter squash, pumpkin, watermelon
Moderate size	Carrot, beet, parsnip, radish, salsify, summer squash

(Source: Adapted from Swaider and Ware 2002.)

It's Time to Harvest!

Harvest in the early morning after the dew has dried or in evening when temperatures are cool. Spinach and Swiss chard, however, are quite brittle in the early morning and may break into pieces during

harvest; wait until midmorning to harvest these. If your vegetables are warm when harvested, remove field heat quickly by submerging them in a tub or sink full of cold water.

Once you have separated a plant part from the parent plant, you have destroyed its source of water, nutrients, and sugars. What it had in it at that moment of harvest is the most the crop will have from now on. The warmer the crop temperature, the more quickly it will use up its reserves and the shorter time it will "keep." Sweet corn loses up to one-quarter of its sugar in a couple of hours at 80°F; peas lose their sugar four times faster at 68°F than at 32°F.

Storage

Some vegetables continue to ripen after harvest and some don't. However, the "ripening" will involve primarily a change of skin color, a softening of the flesh, and perhaps an accumulation of starch or sugar under certain conditions. It usually will not involve much sweetening as the produce, once separated from the plant, has little means of manufacturing new sugars. Root crops and winter squash convert stored carbohydrates into sugars after harvest. Produce ripened off the plant will usually be lower in quality and less tasty than that ripened on the intact plant, so delay your harvest for as long as possible, without delaying for too long.

Most cool-season crops store well just above 32°F. At temperatures below that they freeze and their tissues will begin to rot. Warm-season crops like peppers and cucumbers store best at a temperature around 50°F. If stored at lower temperatures, they develop chilling damage, which often shows up as pitting and sunken areas on the skin. An exception to this rule for warm-season crops is sweet corn: Always store corn close to 32°F to keep sugars from turning to starch. If stored below about 38°F, potatoes convert their starch into sugar. If you fry those potatoes, they will develop black spots where the sugars have caramelized.

Most vegetables contain about 90–95 percent water and they will lose water to air that is drier, causing them to shrivel. It is therefore important to keep the air in your storage compartment as close to 95 percent relative humidity as possible by sprinkling the produce or compartment periodically and by storing the produce in plastic bags. Be sure the bags have about one 1/4-inch-diameter hole per square foot of surface area for ventilation. Exceptions

include winter squash, dry bulb onions, and garlic, which should be stored at about 65 percent relative humidity after curing to reduce rotting.

To maintain high humidity for root crops and cabbage, some folks store them in a box filled with moist sand placed in an unheated basement or crawl space kept at about 55°F. For smaller quantities, I keep my carrots and beets in a spare refrigerator in ziplock bags with the corners cut off. Removing the corners allows gas exchange and excess moisture to escape. Leafy crops stored in plastic containers or bags in the refrigerator will keep fairly well for long periods of time. Hang tomato vines with both green and ripening fruit upside down in a cool room. This allows the fruit to continue the ripening process while extracting some nutrients from the plant itself.

Ideal Storage Conditions and Storage Lifespan

Crop	Storage (°F)	Relative humidity (%)	Approximate storage life
Asparagus	32–35	95	2–3 weeks
Beans (snap)	41–46	90–95	7–10 days
Broccoli	32	90–95	10–14 days
Brussels sprouts	32	90–95	3–5 weeks
Cabbage	32	95–98	1–6 months
Cabbage, Chinese	32	98–100	2–3 months
Carrot	32	95–100	1–3 months
Cauliflower	32	95–100	3–4 weeks
Celeriac	32	90–95	3–4 months
Celery	32	98–100	1–2 months
Cucumber	50–55	95	10–14 days
Eggplant	50–54	90–95	1 week
Garlic	32	65–70	6–7 months
Kohlrabi	32	90–95	2–4 weeks
Lettuce	32	98–100	2–3 weeks
Muskmelon	46–50	90–95	1–2 weeks
Onion, dry	32	65–70	1–7 months

Store only healthy produce in good condition. Produce with bruises, rots, spade cuts on root crops, and damage caused by insects and disease will rot rapidly and liberate large quantities of the ripening hormone ethylene, hastening the deterioration of sound vegetables. Root crops will become more "woody" as they age, so harvest these at a somewhat immature stage if you intend to store them for any length of time.

Crop	Storage (°F)	Relative humidity (%)	Approximate storage life
Peas	32	95–98	1–2 weeks
Pepper	46–54	90–95	2–3 weeks
Potato	39	90–95	4–8 months
Pumpkin	50–55	50–75	2–3 months
Radish, topped	32	90–95	3–4 weeks
Rhubarb	32	95	2–4 weeks
Rutabaga	32	90–95	2–4 months
Salsify	32	90–95	2–4 months
Spinach	32	95–98	10–14 days
Squash, summer	45–50	95	1–2 weeks
Squash, winter	50–54	60	1–6 months
Sweet corn	32	95–98	5–8 days
Swiss chard	32	90–95	10–14 days
Tomato, mature green	54–57	90–95	1–3 weeks
Tomato, ripe	46–50	90–95	4–7 days
Turnip, topped	32	90–95	4–5 months
Watermelon	46–54	90	2–3 weeks

(Source: Lutz and Hardenburg 1968.)

Ventilation is necessary for long storage. Ripening produce gives off heat as it respires. Called the "heat of respiration," this can build up in enclosed areas and make it difficult to maintain a cool temperature. Your refrigerator is able to remove this heat, but some simple cold storages may not. If you can, open a window and run a

fan for a few hours to get some fresh air into the storage area. Ventilation will also help remove excess water and ethylene gas given off by ripening vegetables. Ethylene is a natural ripening hormone, and the more ethylene in the atmosphere, the faster the produce will ripen and the faster it will produce more ethylene. Think of it as a "ripening" snowball going downhill, its size ever increasing. Rotting vegetables, as well as sound apples, bananas, pears, plums, muskmelons, and peaches in particular, give off large quantities of ethylene; never store these among your produce. The old trick about ripening tomatoes by placing them in a bag with an apple (or banana) uses the ethylene produced by the fruit to hasten the process. The less ethylene there is in the storage area, the longer the produce will keep. (Did you know fluorescent lights, engines, and lit cigarettes also emit large quantities of ethylene?)

Keep the lights off in storage. Lights can lead to heat buildup and also cause some produce like onions, garlic, and potatoes to turn green. This is potentially serious in potatoes as the greening reaction signals the buildup of the colorless alkaloid solanine, a toxin that can give you a bad stomachache if you eat enough of it.

Some vegetables store better than others. In general, cool-season crops keep longer than warm-season crops. Later ripening varieties keep longer than earlier-ripening vegetables. American dry bulb onions store better than mild European-type onions; root crops store better than fruits. So don't expect cucumbers to store as long as parsnips. If you intend to store a lot of produce, select the right species and varieties.

Adding It All Up

Congratulations! You've grown your own vegetables. You have provided for your family, know where your food came from, understand what inputs were used to help it grow, and allowed your kids to graze the garden. You've grown interesting types of vegetables, not usually found at the store, with tip-top taste and nutrition for your family. Enjoy your rewards!

The Vegetables

Overview of the Vegetables

I'm a professional horticulturist, but you don't have to be one; a little knowledge goes a long way in the vegetable garden. For example, vegetables may be classified according to botanical classification, edible portion of the plant, life cycle, temperature requirements, or hardiness. Knowing the different ways vegetables are similar to one another is quite helpful, as it means you can treat them much the same in the garden.

For example, botanically, horseradish, cabbage, turnip and radish are all members of the Mustard family (Brassicaceae) and therefore have similar growing requirements. Cabbage and turnip are members of the same genus, so their growing requirements will be even more similar than those for the members of different genera, such as radish and horseradish. Looking at classification by edible parts, beets, carrots, and turnips all have edible roots and are classified as root crops. Kale, Swiss chard, and lettuce all have edible leaves and are classed as leafy vegetables or greens.

Plants are also classified by life cycle. If a seed germinates and the plant grows, flowers, and goes to seed within one growing season, it is an annual; cucumbers and peas are annual vegetables.

Biennials grow vegetatively their first season and after the chilly winter, grow their flowers and seed in the second year; carrots and beets are biennials. Perennials are not killed by winter temperatures and return year after year; asparagus and rhubarb are good examples. Some plants may be botanical biennials, like cabbage, but we usually grow them as annuals for food.

One of the most useful methods of classifying vegetables for those of us living in the Rocky Mountains is by temperature requirements and hardiness. This allows us to separate the cool-season from the warm-season vegetables. Cool-season vegetable seeds germinate at a lower soil temperature, allowing anxious gardeners to get out and plant at an earlier date. The young plants are frost tolerant and hardy. For the most part, cool-season vegetables are smaller plants than warm-season vegetables, and because the plant material above the ground is smaller, their root system is also smaller. We almost always consume the vegetative parts of cool-season vegetables, including roots, immature flower buds, leaves, and stems. Peas are an exception.

Cool-season vegetables can be annuals grown as annuals, biennials grown as annuals (or as biennials for seed-saving purposes only), and perennials grown as annuals or perennials. Sound confusing? It really is quite simple. We harvest biennials for consumption during the vegetative stage, as the plant is making those leaves and roots sweet and full of nutrition to feed the second season's growth. If we don't harvest biennials the first season, the plant uses all those sugars and nutrients to form flowers and seeds in the second season, thereby making the parts we would normally eat—leaves, roots, and stems—woody and tasteless. Some perennials may not be winter hardy in much of our region. Take artichokes, which are technically perennials. In mild climates (USDA hardiness zone 7 and above) the plant produces year after year but will winter-kill in cooler climates. Now, that doesn't mean you can't transplant an artichoke into your garden and reap the harvest in 1 year. Just be sure you set transplants and give them plenty of time and space. Perennials such as asparagus, rhubarb, and horseradish are winter hardy in most of the habitable portions of the Rockies and will produce for you year after year without replanting.

Some cool-season biennials are susceptible to bolting, in other words, flowering and producing seed, if exposed to too much cool weather for any length of time in their first season. *Attention seed savers: Do not save seeds from biennials that bolt the first year, as you'll simply be perpetuating the characteristic of forming seeds instead of edible plant material!*

There are temperatures that are optimal for each crop to produce their best growth. Warm-season crops grow best between 65°F and 85°F, while cool-season vegetables make optimal growth between 55°F and 65°F. Within the classification of cool-season and warm-season, there are subcategories of hardy, half-hardy, tender, and very tender plants. These subcategories are used to define the ability of young plants to withstand frosts and their seeds' ability to germinate at low temperatures.

A Note Regarding Asian Greens, Okra, Sweet Potato, and Callaloo

No discussion of which vegetables to grow in the Rocky Mountain region would be complete without mentioning Asian greens.

Unfortunately, or fortunately, there could be an entire book written about the wide variety of greens available to plant and easy for us to grow. Asian greens can be ready in as little as 21 days. Some are leafy and some are stemmy. There are mild and quite zippy varieties. Get a good catalog or visit a website (see Selected References and Resources) and enjoy the harvest! Because flea beetles can be problematic to most Asian greens, it's recommended you use a row cover from the day of seed sowing!

Tatsoi (front) and Komatsuna (rear) are two Asian greens that are easy to grow in Rocky Mountain gardens.

There are some vegetables that are particularly challenging to grow in most Rocky Mountain conditions. I firmly believe if you throw enough money toward growing a vegetable, it can be done.

But there are so many other choices that are easy and just plain cheap that, unless you enjoy a challenge or want to experiment, I recommend you don't waste precious garden space with warm-weather plants like okra, sweet potato, or callaloo. I tried okra one year in my Montana garden, and while I did succeed in growing some plants, they simply survived and did not thrive. For my efforts I grew one okra pod to maturity. Sweet potatoes thrive at around 75°F and *require* warm nights, which is unusual in the Rocky Mountain region. A minimum growing season of 100–140 days is also necessary, which, needless to say, is highly unusual in our region without high tunnels (hoop houses) or heated greenhouses. Some varieties require 4–5 months for full plant development. As for callaloo (*Amaranthus cruentus*), my seed sprouted, but the plants did not grow any further than the cotyledon stage. This is not surprising. Bob and I ate callaloo every breakfast when we visited Jamaica. It's a nutritious, staple green there. But that's Jamaica. And this is Bozeman, Montana. 'Nuff said.

Layout and Quick Tips

Individual entries in The Vegetables section are presented in alphabetical order and labeled according to four categories: perennial vegetable, perennial vegetable grown as an annual, cool-season vegetable, or warm-season vegetable. Heading each vegetable entry is a series of quick tips on cultivation requirements.

Genus, species, and family. It is useful to know the botanical relationship of the various vegetables because those that are closely related often share the same cultural requirements and the same pest problems. It should be noted that since the previous edition of this book was published, nomenclature has changed due to genetic comparison studies. As a result, some families have been renamed; this new edition uses the currently accepted (as of 2015) family, followed by the former family in parenthesis.

Soil temperatures. Sowing seeds at the minimum soil temperature is skirting danger as they may not germinate at all or germinate so slowly as to be highly susceptible to seed rots. Try to sow when soil temperature is in the optimum range for plant growth.

Distance between rows. This is somewhat dependent upon what equipment you use for cultivation. The old recommendations

were established for cultivation using horses! If you intend to forgo the horse and use a hoe only, you may use closer spacing. The optimum spacing allows for cultivation and for the foliage of mature plants to cover the space between rows, thus crowding out weeds.

Direct seed or transplant. An entry of “Either” indicates our season is long enough in most cases to direct seed this crop, but you may also transplant it for especially early harvests.

Ease of transplant. Some plants tolerate transplanting well because they reestablish their root systems rapidly and continue their growth soon after. Others are slow to reestablish their root systems and resume growth, and will suffer great and sometimes fatal setbacks following transplanting.

Days to maturity. This is not a real number but a composite average for a particular crop planted in an average soil in an average year under average conditions. Meant as a relative guide only, it’s the best we’ve got.

Depth of root system. Contrary to popular thought, some vegetables have extraordinarily deep root systems. The deeper the roots, the more able the plant is to tolerate dry conditions and to mine subsoil nutrients; the more shallow the root system, the more often you will have to irrigate and fertilize to keep plants healthy. A plant with a shallow root system has most of its roots in the top 2 feet of soil, while one with a moderately deep root system has most of its roots in the top 4 feet of soil; roots of deep-rooted crops extend to depths of 6 feet or more. Absolute depth depends upon absence of a hardpan, soil texture, height of the water table, depth of water, oxygen, and nutrient availability.

Consumption of nitrogen. Some plants require a lot of nitrogen for best vegetative growth and crop production and are termed “heavy feeders.” These deplete the soil rapidly if supplemental nutrients are not supplied in fairly large quantities. Pay close attention to fertilizing these crops.

Average yield per 10' row. This is highly variable and subject to modification by cultural practices, temperature, variety, and growing season.

Some vegetables are frequently set to the garden as transplants. For these plants, you’ll find these additional Quick Tips:

Approximate length of the germination period. This figure is highly variable and depends upon the temperature. Generally, lower temperatures lengthen this period, and higher temperatures shorten it. Your goal is for seeds to germinate in the shortest amount of time.

Optimal indoor germination temperature. This temperature can be different from the outdoor, direct-seeded temperature. This is due to the ability to finesse soil temperatures with readily available calibrated sub-media heating mats.

Approximate time to grow to transplant size. Again, this is highly dependent upon temperature. Low temperatures prolong the time needed and may result in woody plant material that is slow to recover from transplant shock. Very high temperatures produce soft, spindly plants that don't do well in the garden.

In addition to the above Quick Tips, watch for other special hints for specific vegetables.

Finally, every vegetable gardener has their favorite vegetable varieties to plant. Novices should go with tried-and-true varieties until they get their feet wet. New varieties also become available and old varieties— particularly heirlooms—go away, only to resurface a few years later. Look for my suggested varieties, but by all means, do not be limited by my lists! Got it? Here we go—let's get growing!

Artichoke, Globe

Cynara scolymus
Family: Sunflower / Asteraceae (formerly Compositae)

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 60–65˚F
Minimum Soil Temperature for Planting: 45˚F
Transplant Spacing within Row: 48–72"
Days to Maturity: 85–95
Distance between Rows: 84–96"
Depth of Root System: Deep
Ease of Transplant: Easy
Consumption of Nitrogen: Heavy
Average Yield per 10' Row: 5–10 buds per plant

Fun Fact

This herbaceous perennial originated in North Africa along the Mediterranean Sea. Its wild form, called "cardoon," was prized by the Romans. First cultivated in Naples for its large flower bud, by the sixteenth century it had become generally popular throughout Europe. It reached England from Italy in 1548. It was brought to the United States before 1800 by French settlers in Louisiana and by Spanish and Italian farmers in California.

Globe artichokes are grown as annuals in some short-season areas, and as perennials in USDA hardiness zone 7 and above. It is marginally adapted to our region. Use caution when selecting seed from a catalog to be sure your variety is bred for annual production. Artichokes are space hogs, so be sure you have enough room in your garden. I planted 1 artichoke, and it well exceeded 5' in diameter! With their beautiful flowers, artichokes are fun to grow,

and many gardeners think they're worth the space, but don't give up garden space at the expense of needed food crops.

Globe artichoke buds are killed at temperatures below freezing, and high temperatures toughen and partially separate the bud scales.

Planting and Care: A rich, fertile loam produces the best artichokes, and moisture is especially critical during bud formation.

Aphids, congregating in hidden masses beneath the outer bud scales, can be a problem. Remove a few of the oldest, outer bud scales to check for their presence.

What Happened Here?

The leaves of my artichoke are curled and deformed. Check the undersides of those leaves for aphids, and if you find them, give the plants a good squirt with the garden hose, taking special care to hose the undersides of the leaves.

My plants suddenly wilted even though I gave them plenty of water. Verticillium could be the cause. This pathogen clogs the water-conducting channels in the plant and can live for many years in the soil. Follow a long rotation, planting no crops susceptible to Verticillium wilt (especially vine crops and the nightshades) in that garden spot for at least 5 years.

Harvesting: Harvest the buds by cutting the stem about 2" below the base of the bud. Terminal buds will be largest, up to 3–5" in diameter.

Suggested Globe Artichoke Varieties

Variety	Days to maturity	Comments
Green Globe	Entire season	For areas with the longest growing seasons; tender thick scales, solid core
Imperial Star	85–100	Specially bred for annual production; produces about 6 buds per plant
Lulu Hybrid	100 from transplant	Italian hybrid; theoretically hardy to zone 3
Opera Hybrid	100 from seed	Purple annual; one to three 3–4" primary buds followed by several smaller ones

Artichoke, Jerusalem

Helianthus tuberosus
Family: Sunflower / Asteraceae (formerly Compositae)

Direct Seed or Transplant: Plant tubers
Optimum Range of Soil Temperature for Planting: 50–70˚F
Minimum Soil Temperature for Planting: 50˚F
Planting Depth for Tubers: 2–3"
Depth of Root System: Shallow
Spacing within Row: 24–30"
Consumption of Nitrogen: Moderate
Distance between Rows: 36–48"
Average Yield per 10' Row: Highly variable
Days to Maturity: Harvest any time after killing frost

Fun Facts

Scientists believe the Jerusalem artichoke developed from a wild sunflower species in the Mississippi River valley. Early colonists found the Native Americans growing it along the Massachusetts coast and sent specimens to Europe. Europeans gave it the Italian name girasoli articocco *meaning "sunflower artichoke," which was then corrupted and anglicized to "Jerusalem artichoke," the name that first appeared in 1686. By 1806, the plant had become common in American gardens, and varieties bearing white, yellow, and purple skins were grown before the Civil War.*

There is some confusion in the literature regarding a type of carbohydrate found in the tubers. Most of the carbohydrates are in

the form of inulin. Don’t confuse this with insulin, a protein important in sugar metabolism and often lacking in diabetics.

Planting and Care: The plant’s knobby tubers are planted in the early spring 3" deep and 3' apart in rows 3–4' apart. Light soils produce smaller yields than slightly heavier soils but make harvest easier. Grow the plants as you would potatoes. Plants grow to several feet tall and resemble sunflowers.

Harvesting: The tubers form as days shorten in late summer and early fall and are dug after the tops have been killed by frost. Failure to harvest all of the tubers will lead to a very “weedy” situation as volunteer plants grow in unwanted places. In some neglected patches the only way to clear the ground is to let hogs root out the tubers, which they very much enjoy.

What Happened Here?

My Jerusalem artichoke leaves have a white powder coating on them and feel dry. This sounds like powdery mildew. Avoid wetting the foliage during irrigation and be sure to rake up and remove from the garden all dead leaves and plant material at the end of the season. Good sanitation is about all you can do here.

This year I planted strawberries where my Jerusalem artichokes grew for the past few years, and I have the artichokes coming up everywhere. This plant can be very pesky, easily becoming a weed if you fail to dig all the tubers in a season. Dig them all up every year. Or, dig a trench 18" deep around the planting and line the sides with double-thick polyethylene sheeting to prevent the tubers from spreading.

Refill the trench and repeat the operation every 6–8 years.

Suggested Jerusalem Artichoke Varieties

Variety	Days to Harvest	Comments
Stampede	90	One of the earliest maturing; large white tubers up to ½ lb.
Red Fuseau	Full season	Midsize; dark red skin; cylindrical tubers
Jack's Copperclad	Full season	Tubers coppery purple

Asparagus

Asparagus officinalis
Family: Asparagus / Asparagaceae (formerly Liliaceae)

Direct Seed or Transplant: Transplant 1- to 2-year-old crowns
Optimum Range of Soil Temperature for Planting: 75–85˚F
Minimum Soil Temperature for Planting: 50˚F
Spacing within Trenched Row: 8–14"
Depth of Root System: Deep
Trench depth: 6–8"
Consumption of Nitrogen: Low
Distance between Rows: 3–5'
Average Yield per 10' Row: 3 lb.

Asparagus is a hardy, dioecious herbaceous perennial. It tolerates severe cold when dormant and grows best when daytime temperatures average about 80˚F and nighttime temperatures fall to about 60˚F.

Planting and Care: Prepare the soil using plenty of organic material and till in a fertilizer high in phosphorus and potassium; well-drained, sandy loams are best.

Fun Fact

Asparagus originated along seashores and riverbanks from Siberia to the British Isles and the Mediterranean. The Roman statesman Cato gave directions for its cultivation about 200 BC. Pliny and Columella spoke highly of it, and the emperor Augustus apparently relished the young shoots. Introduced into the United States very early in our history, it was not planted extensively until about the time of the Civil War.

Purchase 1- or 2-year old disease-free crowns, each containing 2

or more well-formed clusters of buds. The roots should appear plump and white, not brown and squishy. Seeds are also available but seedling vigor is highly variable; let the pros weed out the runts and buy selected crowns from them.

Place the crowns in a trench about 8" deep and spread the roots carefully. Cover them with 1–2" of soil. Continue to fill in the trench as the shoots grow until you have regained the original soil level, allowing the top 1–2" of the shoot to remain above the soil as you fill the trench. If your soil is heavy, plant the crowns only 4" deep. Asparagus is susceptible to *Fusarium*, so plant on ground that has not been planted previously to asparagus.

What Happened Here?

My asparagus is woody. Slow growth. The bed is probably too crowded or conditions were droughty.

My plants have rusty spots. Asparagus rust is the most common cause of failure in asparagus beds. Destroy the existing bed and plant rust-resistant varieties in a new

location.

My asparagus tastes bitter. Weather is probably too warm. Quit harvesting.

Slide-dress plants in early spring and again after harvest. Some gardeners also top-dress with rotted manure after harvest to keep plants vigorous.

Watering is critical while plants are becoming established. By the third season the plants should have an extensive root system and require less water.

Keeping weeds out of the bed can become problematic as the crowns begin to spread and the rows to fill in. Also, some volunteer asparagus seedlings may appear. These will not be as vigorous or productive as the mother plants, so consider them weeds and keep them out of the bed.

Older varieties are based on the 'Martha Washington' strain, but breeders have developed a number of all-male or predominantly male varieties. Male plants produce as much as 3–5 times more spears than a mixed population of older varieties, where male and female plants will be present in approximately equal proportions.

Suggested Asparagus Varieties

Variety	Comments
Mary Washington	Heirloom; old standby
Pacific Purple	Purple shoots turn green when cooked
Jersey Knight	Male variety
Jersey Supreme	Male variety

Crown Development: The combination of perennial rhizomes and fleshy roots make up the crown of the plant. The rhizomes grow in a slightly upward-pointing manner. This is the reason that old beds have crowns near the surface. Fleshy roots grow about 6' outward from the plant and 5' deep. Fibrous roots that absorb water and nutrients develop from the fleshy roots and die back each fall.

Spear Development: Spears arise from buds on the crowns and become increasingly woody as they elongate. The rhizome buds will produce only a few shoots unless the early shoots are harvested. New shoots develop as the old are harvested.

The growth of spears is temperature dependent, requiring about 5 days to produce a 6" spear at 53°F but only 2 days at 78°F. Warm temperatures cause rapid growth and decrease the spear quality, though very cool temperatures cause the spears to become woody and bitter and lower their quality as well.

The spears continue to elongate into shoots up to 6' tall. Female plants produce berries. The ferny foliage produces carbohydrates to replenish those used in overwintering the crowns.

Harvesting: Don't harvest the first season and harvest only lightly in the second season. In the third season, harvest spears for the first 3 weeks only, then extend the length of harvest by 2 weeks each year until you've reached a maximum of 6–8 weeks. Spears developing later should be left to produce ferns to make carbohydrates that will be stored in the roots. Stop harvesting immediately if you see pencil-thick spears, for this is a sign the crowns' supply of nutrition is nearly depleted.

The best spears are 6–10" long with tight tip scales. The scales open sooner during warm weather, so you will have to harvest every day.

If you cut the spears about 1" below the soil line, the portion of the spear that was below ground will be white and tough, so trim it off. If you snap the spears at the soil line, you'll eliminate the tough white base and have less trimming to do.

Let all later shoots develop fully and overwinter, removing them before growth begins in the spring.

Bean, Snap

Phaseolus vulgaris
Family: Pea or bean / Fabaceae (formerly Leguminosae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 60–85˚F
Minimum Soil Temperature for Germination: 60˚F
Seed Planting Depth: 1–11/2"
Days to Maturity: 48–62
Seed Spacing within Row: 1–2" (bush); variable (pole)
Depth of Root System: Moderate
Consumption of Nitrogen: Low
Thinned Spacing within Row: 2–4" (bush); variable (pole)
Average Yield per 10' Row: 8 lb. (bush); 15 lb. (pole)
Distance between Rows: 18–36" (bush); variable (pole)

Beans grow best at soil temperatures of 60–85˚F. Seeds will not germinate well below 60˚F or above 95˚F, and seedlings will not emerge from the soil if days have less than about 16 hours of sunlight.

Bean plants will be damaged if temperatures fall below 50˚F, high humidity increases diseases, and high temperatures during flowering cause the flowers to abort. Hot, dry winds also injure the flowers, reducing pod set.

Planting and Care: Beans have 3 growth habits. *Indeterminate* varieties produce climbing vines several feet tall. These pole or runner beans must be trellised.

Fun Facts

Beans were grown in Central America at least 7,000 years ago. Columbus introduced them into Europe, from whence they were carried throughout the world by the Portuguese and Spanish. Colonial settlers in New England adopted Native American ways of growing and preparing beans, such as succotash and Boston baked beans.

The snap bean is also called the string bean, though most varieties today have no strings. (Strings were the fibrous material in the pod that had to be removed to make the bean palatable.) This characteristic was selected out of varieties over a century ago, but the name persists. Snap bean pods are cylindrical or flat, 3–8" long, and green, yellow, purple, and even striped in color. Seeds can be yellow, white, purple, red, green, black, or brown. They can also have intriguing patterns.

Bush beans are determinate and reach a height of 8–24". They are less apt than pole beans to suffer damage in windy locations. The stem tips end with a flower cluster, thus limiting vegetative growth. The half-runner is *semi-determinate* and reaches heights of several feet. Bush beans are the favorites of many gardeners, although pole beans certainly give you greater yield in the same space.

The bean root system has nodules that contain the *Rhizobium* bacteria. These bacteria convert atmospheric nitrogen into a form useful to the plant. You can buy packages of these bacteria as inoculant to treat your bean seeds before planting, but you don't have to. The bacteria are usually present in the soil, and there is no conclusive evidence that this increases yields.

Trellis pole beans when you plant the seeds, or plant 4–6 seeds at the base of each leg of a tripod made of 8' poles 1–2" in diameter. You'll damage the root systems if you try to erect a trellis after the plants are up.

Beans are low to moderate feeders and show little response to fertilizer. Fertilizer applied prior to planting ("preplant") will satisfy their needs for the season. They are very sensitive to salts, so keep all fertilizers at least 8" away from the plant stems. Excessive nitrogen causes excessive vine growth, reduces pod set, and delays maturity.

Beans are very sensitive to moisture stress as well. Lack of water, especially during flowering, decreases yield.

What Happened Here?

My bean plants dropped their flowers and small pods. Hot weather and moisture stress during flowering causes this.

My bush beans look like small pole beans. You may have applied too much nitrogen.

My bean leaves have cottony patches on their under-sides. It sounds like mildew. Pull and discard infected plants. Do not compost!

Besides classifying beans as pole or bush, we group snap beans by pod shape (cylindrical or flat), and by whether or not they will be shelled. Beans grown for their immature green seeds are called "horticultural" snap beans, while those grown for their mature seeds are called "dry" shell beans.

Bush beans have shorter seasons and ripen all at once, while pole beans ripen over an extended period, making them more useful for smaller families.

Harvesting: Harvest snap beans about 50–80 days after planting, depending upon variety and growing conditions, picking the pods when they are about 3–5" long and while their seeds are still small and tender. Large bumps along the pods indicate seeds that are overmature.

Dry shell beans ought to remain on the plants until the pods mature and dry.

Suggested Snap Bean Varieties

Variety	Days to maturity	Comments
Tendercrop	54	Heirloom; green, bush; 5–6" pods
Jade	53	Green, bush; 6–7" pods; stress tolerant
Provider	50	Green, bush; 5" pods; widely adapted; dependable
Goldrush	53	Yellow, bush
Rocdor	52	Yellow, bush; 6" pods
Royal Burgundy	55	Purple, bush; 5" pods
Kentucky Wonder	64	Heirloom; green, pole; 9–10" pods
Romano	65	Green, pole; freezes well

Beet

Beta vulgaris var. *crassa*
Family: Goosefoot / Amaranthaceae (formerly Chenopodiaceae)

Direct Seed or Transplant: Either, but usually direct seeded
Optimum Range of Soil Temperature for Germination: 50–85°F
Minimum Soil Temperature for Germination: 40°F
Optimum Range of Soil Temperature for Planting: 60–65°F
Minimum Soil Temperature for Planting: 40°F
Seed Planting Depth: 1/2–1"
Days to Maturity: 56–70
Seed Spacing within Row: 1"
Depth of Root System: Moderate
Thinned Spacing within Row: 2–4"
Consumption of Nitrogen: Moderate
Distance between Rows: 12–30"
Average Yield per 10' Row: 10 lb. roots, 4 lb. greens
Ease of Transplant: Easy

Beets are grown for their roots and tasty greens. They are easy to grow from seed and easy to transplant. But you probably don't know that the "seeds" in the packets are actually clusters of seeds within a shriveled fruit. If you grow beets for pickling, stick with the red varieties. My gold beets turned an unappetizing gray when pickled.

Planting and Care: As seeds germinate, the resulting plants don't come up all at once. The weak seedlings cannot push through crusted soil, so be on guard! Plant radish seed as a nurse crop. Thin young plants when their roots and tops are large enough to eat. Succession planting may be used in longer season regions, through the spring and again in late summer for a fall crop.

Some varieties are only grown for their greens, so be diligent about controlling leaf miners. 'Bulls Blood' is an heirloom variety with—you guessed it—blood-red foliage, a beautiful addition to anyone's salad bowl!

Beets are biennials grown as annuals, forming a rosette of leaves and thick tap root the first year and a flower stalk the second. Because of this 2-year growth pattern, sudden, drastic changes in the weather or low temperatures (40–50°F) for more than a couple of weeks while seedlings are small will cause the plants to flower and set seed (bolt).

Prolonged high temperatures result in zoning and low sugar content in the roots. Zoning is undesirable in some varieties, but not all. In fact, many gardeners plant ‘Chioggia’ beets for the beautiful candy-striped zones. Beet roots also develop poor color if dry periods are followed by heavy rains.

Good, deep loamy soils produce the best beets. Heavy soils produce asymmetrical roots. Beets must make rapid growth to develop the best quality, and they respond well to organic matter. Apply composted manure as well as preplant fertilizer and side-

dress 4–6 weeks after planting. Take care not to apply too much nitrogen, however, since that will force excessive top growth and faded root color (unless you are growing for greens only).

Fun Fact

Since the very ancient Greeks and Romans did not mention beets in their writings, they are probably of fairly recent origin. The Roman author and naturalist Pliny recommended that people eat a roasted beet to sweeten their breath, and Greeks offered them in silver bowls to Apollo. Beets were used as medicine in the second century AD and eaten as food by the third century. Roman gardeners selected both red- and white-rooted types for the table. Beets were first grown for cattle feed in northern Europe. Around AD 1400, the author of an English cookbook mentions beets grown for the table, and they soon became widely grown in Europe, beginning in Germany by 1558. They were known as "Roman beets" in England in 1576, suggesting they came from Italy. They were being grown in the United States by 1800.

What Happened Here?

My beet roots are brown inside. High pH soils together with hot, dry conditions can cause a boron deficiency. Test your soil before next year's planting. Don't supplement soil with boron without a professional recommendation, as you can sterilize the soil.

My leaves have brown areas. Leaf miner adults lay their eggs on leaf tissue. The young maggot-like leaf miner tunnels between the upper and lower epidermis, leaving dead, brown tissue behind. Remove badly damaged leaves from your garden and destroy them. If you plan to eat the leaves, simply snip out the slightly damaged areas. Exclude the adult leaf miner from your crop by using a row cover at planting.

My beets are tough and woody. Conditions that cause the beet growth to slow can cause woodiness. If you forgot to thin, or planted too thickly, the beets will compete with each other like weeds for water and nutrients. Very hot weather also causes woody beets.

I have seed stalks on my plants. Beets are biennials and can be fooled into producing their flower and seed stalk the first

year by an extended cold snap soon after you've seeded. When this happens, the plant's reserves go to developing seeds, not sugars in the roots. Pull them up and plant again if it isn't too late. Beets that mature in the heat of summer will be poor quality.

Beet greens look ragged when the beets are grown in low pH soils. In fact, early gardeners used them as indicator plants for acid soils. Have your soil tested for boron also, as beets are sensitive to low levels of this nutrient.

Suggested Beet Varieties

Variety	**Days to maturity**	**Comments**
Bull's Blood	35 for baby leaves	Heirloom; grown mostly for tops
Chioggia	55	Heirloom; attractive red-and-white striped zoning
Detroit Dark Red	45–70	Heirloom; widely used
Early Wonder	45	Heirloom; arguably one of the earliest
Red Ace	50	Little to no zoning; widely adapted
Golden	55	Heirloom; green leaves, yellow stems, gold root interior

Few pests attack beets. Leaf miners are among the most troublesome insects, eating the juicy tissues between the leaves' upper and lower epidermis, rendering the greens unfit to eat without trimming. Boron deficiency shows up as internal browning. Corky black spots appear in the root, and the young leaves resemble straps and sometimes turn a deep red. Boron deficiency is often a problem in dry conditions and neutral or alkaline soils.

Harvesting: Harvest when the roots have reached about 11/2" in diameter and store them just above 32°F. If you plan to eat the tops, remove and store them separately, but leave 1" or so of the stem attached to the beet to prevent "bleeding" and desiccation.

Broccoli

Brassica oleracea (Italica group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 60–65°F
Minimum Soil Temperature for Planting: 40°F
Transplant Spacing within Row: 12–24"
Days to Maturity: 55–78
Distance between Rows: 18–36"
Depth of Root System: Shallow
Ease of Transplant: Easy
Consumption of Nitrogen: High
Average Yield per 10' Row: 71/2 lb.

Grow Your Own Transplants
Optimum Range of Soil Temperature for Germination: 65–70°F
Approximate Length of Germination Period: 3–4 days
Approximate Time to Grow to Transplant Size: 4–6 weeks

Broccoli tolerates light frost, which improves its flavor, but it bolts during hot summers, doing best at temperatures between 57°F and 68°F. Slightly higher temperatures produce leafy heads that bolt quickly, while at temperatures above 77°F plants will form no heads at all.

Fun Fact

Scientists believe that our common broccoli arose as a mutation of wild cabbage growing along the European coasts. Pliny mentions its culture, but the issue is confused because the same Latin name cyma is applied to both broccoli and cauliflower. Both green and purple-colored broccoli were introduced into England in 1724 where they were called "sprout colli-flower" and "Italian asparagus." Broccoli was introduced into the United States about 1800 but remained obscure until doughboys returning from Europe after World War I began to ask for it. California farmers of Italian origin or descent shipped the first commercial freight of broccoli east in 1920, and the vegetable has continued to gain popularity ever since.

Planting and Care: Transplant broccoli in early spring or direct seed it later to mature in the fall. In either case you should plan to harvest the heads before or after the heat of summer. In our region, with its short growing seasons, broccoli is usually transplanted as a spring crop. Transplant younger plants (6–8 weeks), as older transplants of both broccoli and cauliflower may form tiny, poor-quality heads if exposed to temperatures below 50°F.

All brassicas need rich soil with plenty of manure and compost for best production. Their need for nutrients is high, so don't be shy about side-dressing each plant. Since most brassicas have cultural requirements similar to those of cabbage, see that vegetable for more details.

Ask your soil-testing lab to check soil levels of boron and molybdenum, as broccoli is very sensitive to deficiencies of these. Never add these nutrients to the soil unless you are sure they are deficient, and never add more than is recommended. In soils below pH 5.5, molybdenum deficiency causes "whiptail," the development of straplike leaves.

Suggested Broccoli Varieties

Variety	Days to maturity	Comments
Calabrese	58	Heirloom; produces many side shoots
Goliath	53	Early; produces many side shoots
Premium Crop	58	1975 AAS Selection; bolt resistant
Packman	50	Early; widely adapted
Windsor	56	Heat tolerant; widely adapted

What Happened Here?

Leaves have developed in my broccoli flower heads. This can be caused by too much heat. Time the planting so the heads mature in cooler weather. Heads in this condition are not desirable but remain perfectly edible.

My broccoli plants wilt and some turn yellow a few weeks after transplanting. Pull up a plant or two and look at the roots. If root maggots are present, side roots will be absent, and you'll find the tiny maggots burrowing into the stem. Rotate your crop next year and protect the transplants with row covers or small pieces of tar paper placed on the soil around the plants' stems.

Broccoli plants are weak and yellow but have no root maggots. If the main root is malformed, then clubroot may be the problem. Rotate your crop next year and be sure to plant only treated broccoli seeds.

Are the pretty white butterflies around my broccoli eating holes in the leaves? Cabbage worms are very destructive to all brassicas. Use row covers to prevent the adult butterflies from laying their eggs. Disinfest heads prior to eating by soaking them in salt water.

Boron deficiency causes "browning," wherein the stems develop water-soaked areas that develop upward into the flower head; individual flowers then become brown.

Harvesting: Cut the tight central head when it is 3–6" in diameter, along with 8–10" of stem. If the head is loose and the yellow florets have opened, you waited too long and the broccoli may taste bitter or simply insipid. After the harvest of central heads, side-dress the

plants with a fertilizer relatively high in nitrogen to promote strong development of the lateral shoots. These are harvested when their heads are about 2" in diameter. You may use a small handful of 10-5-5 or a larger handful of dried blood meal applied in a ring around each plant and about 8" from its base.

Brussels sprouts

Brassica oleracea (Gemmifera group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 60–65˚F
Minimum Soil Temperature for Planting: 40˚F
Transplant Spacing within Row: 18–24"
Days to Maturity: 90–100
Distance between Rows: 24–40"
Depth of Root System: Shallow
Ease of Transplant: Easy
Consumption of Nitrogen: High
Average Yield per 10' Row: 6 lb.

Grow Your Own Transplants
Optimum Range of Soil Temperature for Germination: 65–70˚F
Approximate Length of Germination Period: 3–4 days
Approximate Time to Grow to Transplant Size: 4–6 weeks

Brussels sprouts tolerate cold better than some other brassicas, surviving temperatures below 20˚F with little damage. Low temperatures mellow and improve the flavor of sprouts and help the plant form tight, compact buds. As with the other brassicas, heat is the bane of good Brussels sprouts and will turn them into a loose, soft, and strong-flavored catastrophe.

Planting and Care: Like the other brassicas, Brussels sprouts need rich, fertile soil with plenty of organic matter worked in. Because it is a long-season crop, side-dress it about a month or so after transplanting to encourage rapid growth. But be careful, as too much nitrogen can cause unproductive plants with loose sprouts. See the cabbage entry for more details on cultural requirements.

Suggested Brussels Sprout Varieties

Variety	Days to maturity	Comments
Jade Cross	80	1959 AAS Selection; old standby
Tasty Nuggets	78	Very sweet; very vigorous plants
Long Island Improved	80	Heirloom; relatively compact plant

As with broccoli, this plant is usually transplanted in our region due to our short seasons.

What Happened Here?

My plants stopped growing and formed no more sprouts. There are many reasons for this, including lack of water, lack of nutrients, and excessive heat.

The lower sprouts are large and compact but my upper sprouts have lower quality. Don't remove all the leaves at the same time but rather snap each off just before the sprout next to it is ready to harvest. Taking a leaf off too soon lowers the quality of the bud nearest it.

Fun Fact

Like broccoli, Brussels sprouts developed from wild cabbage and very quickly became popular in northern Europe. Rumor has it that Brussels sprouts were first discovered growing in the fields around

Brussels, Belgium, in the 1600s. By 1821 it had become widely popular in Belgium and France. American gardeners were growing it by 1800 and English gardeners by 1854; however, it was not cultivated widely throughout Europe and the United States until the end of World War I. It's a non-heading cabbage grown for its axillary buds, and most gardeners agree that the sprouts we grow ourselves taste far superior to the store-bought ones.

Harvesting: Sprouts will be ready for harvest about 14 weeks after transplanting, but rely upon the plant to indicate when to harvest. When the lower leaves begin to lighten in color to a yellow-green and the lower sprouts are firm and about 1" or slightly more in diameter, it's time to begin the harvest. If you wait too long after the leaf color begins to yellow, the sprouts will turn tough, loose, and strong flavored. Remove the leaf by cutting at its base, and then cut the bud from the stem. Begin with the lowest leaf and bud and continue along up the stem as each sprout becomes harvestable. The plant will produce new leaves and sprouts at its top as harvest of lower buds continues, with each plant potentially producing up to 100 sprouts before the season ends. Remove the leaves at each bud just before harvest, as removing them too far in advance will reduce yields and flavor.

If your season is shaping up to be a short one, you can borrow a trick from English gardeners to speed harvest. Remove the top (terminal) bud after the lower sprouts have begun to form. This increases the size of each sprout and may increase total yield on a weight basis, but it will reduce the total number of sprouts.

Cabbage

Brassica oleracea (Capitata group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 60–65°F
Minimum Soil Temperature for Planting: 40°F
Transplant Spacing within Row: 12–24"
Days to Maturity: 62–120
Distance between Rows: 24–36"
Depth of Root System: Shallow
Ease of Transplant: Easy
Consumption of Nitrogen: High
Average Yield per 10' Row: About 6 heads

Grow Your Own Transplants

Optimum Range of Soil Temperature for Germination: 65–70°F
Approximate Length of Germination Period: 3–4 days
Approximate Time to Grow to Transplant Size: 4–6 weeks

Although well-hardened cabbages tolerate temperatures in the low 20s, they won't grow well at temperatures below 40°F. Cabbage grows best between 60°F and 65°F and stops growing above 75°F, so don't plant it to mature during the summer.

Fun Fact

Cabbage has been used as food for more than 3,000 years. Prior to that, cabbage was considered to be medicinal only and was worshipped by the Egyptians almost 5,000 years ago. Ancient Greeks also esteemed cabbage. These ancient loose-headed cabbages were introduced by the Romans and Celts 2,000 years ago to residents on the coasts of southern England and Brittany, and became the ancestors of our modern heading varieties.

Cabbage was commonly grown in Europe by AD 900 and modern heading types in England by 1536. Most of these firm-headed types were developed in northern Europe; the savoy type was developed in Italy. Cabbage was brought to Scotland by the English statesman Oliver Cromwell in 1649 and later made it to North America, being introduced into Virginia by 1669.

Cabbage is a biennial grown as an annual for its enlarged vegetative bud. The first leaves remain as outer leaves, the head growing from the inside out. As inner leaves are produced and become tightly packed against the outer leaves, the head becomes firm and compact. When moisture is excessive or soil nitrogen levels very high, the primary head will split and several smaller heads will form. The smaller heads resemble Brussels sprouts and are edible.

If exposed to temperatures of 40–50˚F for more than a month or so, or to lower temperatures for less time, the head will split and the plant will bolt. This is primarily a problem with plants that have at least 3 or 4 leaves, or stems thicker than a pencil, at the time of exposure.

Like all brassicas, cabbage needs adequate moisture and high fertility with a slightly acid to slightly alkaline soil. A pH of 7.5 or slightly higher to control clubroot, along with a 4-year rotation and good sanitation, works well for our region. Spring cabbages are usually transplanted to the garden a couple of weeks before the last frost is expected.

What Happened Here?

My cabbage heads split open. Maintain steady watering and

harvest as soon as heads mature. If the heads begin to crack, stop watering and twist the plant to break some of the roots or use a spade to sever roots on one side of the plant. In warm weather, heads of early varieties sometimes split a week or so after they mature.

The cabbages are full of holes. This is probably cabbage worms feeding. Apply Bacillus thuringiensis (Bt) as soon as you see white moths around the plants.

My cabbage heads are small. Did you plant a small-headed variety or space your plants too closely?

Use stocky, medium-sized plants. If you plant earlier, use smaller, hardy plants with no more than 3 leaves to avoid bolting. Don't crowd the plants when transplanting since the closer you space your cabbages, the smaller the mature heads (unless you want smaller-sized heads).

Planting and Care: Fall crops are often sown where they will mature. Thin plants to their final in-row spacings (12–24") when they are about 2–4" high and before they become crowded. Direct-seeded cabbage will often mature 2–3 weeks earlier than transplants.

Like all brassicas, this crop responds well to highly fertile soil; turn under plenty of organic matter. Broadcast a complete fertilizer such as 5-10-10 before you plant and side-dress the plants when they are about 4–6" tall. Don't fertilize when plants begin to mature or use too much nitrogen ever, since both can cause the heads to loosen and split and/or the leaves to show tipburn.

Although they have extensive but shallow, dense, fibrous root systems, cabbages and other brassicas are poor competitors. Practice good weed control, but discontinue hoeing as the plants mature. Mulching is a great way to control weeds in brassica plantings.

Cabbage and other brassicas are relatively drought tolerant, in part due to the heavy waxy coating on their leaves. Nevertheless, be sure they get sufficient water each week and that it is applied with a soaker hose or watering can, since wetting the foliage promotes the spread of black rot and *Alternaria* pathogens. Keep the water supply steady because dry spells followed by heavy watering during head formation may cause the heads to split.

Suggested Cabbage Varieties

Variety	Days to maturity	Comments
Farao	64	Early green; thrips resistant
Copenhagen Market	63	Heirloom; early green; crack resistant
Earliana	60	Heirloom; very early green; 2 lb. heads
Caraflex	65	Small, pointed green heads; disease resistant
Salad Delight	50	Extra early red; 3 lb. heads
Red Express	63	Red; resists splitting
Alcosa	72	Blue-green savoy type; 3 lb. heads

Cabbage can suffer from many nutrient deficiencies. Among these is internal tipburn caused by tissue breakdown near the center of the head. The tissue becomes papery and black. Its cause is related to an imbalance in plant calcium and made worse by uneven watering. It's most common on short-season varieties when water supply is insufficient for rapid growth.

Harvesting: Cut the heads from the plants when they are firm and mature. Leave a few of the older wrapper (outer) leaves on the head. The heads will split if you let them remain on the plants too long after they mature or if temperatures are very high. Late cabbages store the best, holding up for several months; early cabbages keep only a month or two.

Cabbage, Chinese

Brassica rapa (Pekinensis group)–heading napa (pe-tsai) type
Brassica rapa (Chinensis group)–leafy pak choi type
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 60–65˚F
Minimum Soil Temperature for Planting: 45˚F
Transplant Spacing within Row: 10–18"
Days to Maturity: 70–80
Distance between Rows: 18–36"
Depth of Root System: Shallow
Ease of Transplant: Moderately difficult
Consumption of Nitrogen: High
Average Yield per 10' Row: 6 heads

Grow Your Own Transplants

Optimum Range of Soil Temperature for Germination: 65–70˚F
Approximate Length of Germination Period: 3–4 days
Approximate Time to Grow to Transplant Size: 1 month

The bok choy type (also called pak choi and other variants) forms a non-heading, leafy plant resembling mustard; pe-tsai types form a head like romaine lettuce. Both types are sensitive to temperatures below 40˚F, do best between 60˚F and 70˚F, and bolt in long summer days.

Fun Fact

Native to China, Chinese cabbage developed from the wild turnips in the Middle East about 3,000 years ago. It appeared in Europe about 1837.

Planting and Care: Chinese cabbage has soil fertility requirements similar to those of other brassicas (see the cabbage entry) and is attacked by the same pests. Transplant plants less than 4 weeks old to the garden for a spring crop or set them to the garden for a fall crop. If your springs are short, as they are in southwestern Montana,

you may have better luck with the fall crop, as the plants will mature during cooling weather.
Harvesting: Baby Chinese cabbage may be harvested at any time, or cut heads from the stems at the soil line when they are fully developed, about 2–3 months after planting. You can harvest the entire plant this way, too, about 1–2 months after planting, or you can simply harvest the outer leaves periodically until frost.

What Happened Here?

It looks like someone shot my Chinese cabbage with buckshot! Undoubtedly the work of flea beetles—tiny, shiny black beetles that come in on the wind. Next time place a row cover over your crop when you plant it, and leave it there.

Suggested Chinese Cabbage Varieties

Variety	Days to maturity	Comments
Red Choi	45	Bok choy type; red leaves at full size
Joi Choi	45	Bok choy type; very attractive
Toy Choi	30	Bok choy type; very early; small plants
Greenwich	50	Pe-tsai type; very tall; flavorful
Blues	57	Pe-tsai type; vigorous; disease resistant
Jade Pagoda	68	Pe-tsai type; disease and bolt resistant

Carrot

Daucus carota
Family: Parsley / Apiaceae (formerly Umbelliferae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 45–95°F
Minimum Soil Temperature for Germination: 40°F
Seed Planting Depth: 1/2–1"
Days to Maturity: 50–95
Seed Spacing within Row: Sow thinly
Depth of Root System: Moderate
Thinned Spacing within Row: 1–3"
Consumption of Nitrogen: Low
Distance between Rows: 16–30"
Average Yield per 10' Row: 10 lb.

Carrots are biennials grown as annuals for their large taproot, which can reach diameters up to 21/2" and lengths up to 1' or more, depending on soils. Varieties can have white, yellow, orange, red, purple, and purplish-black roots, with orange being the most popular today.

Planting and Care: Carrots grow best between 60°F and 65°F. Top growth is stunted and the roots become strong flavored above 82°F. The roots become long and tapered but develop poor color below 60°F and grow very little below 50°F.

The shape and color of carrot roots depends upon genetics, temperature, and age. Young carrots are lighter in color than mature carrots. The roots develop their best color between 60°F and 70°F and longest length between 50°F and 60°F. The higher the temperature, the shorter the roots. Drought promotes longer roots.

Light soils produce early crops and stone-free soils produce the most uniform roots. Compacted soils cause the roots to grow short and curved. Carrot seeds require a long time to germinate and produce weak seedlings unable to compete with hard soil crusts, so use radish as a nurse crop.

Fun Fact

Carrots are native to Europe, Asia, and North Africa, where they have been cultivated for thousands of years. The ancient Greeks and Syrians used wild carrots medicinally. Galen, a second-century AD Greek, was the

first to mention cultivated carrots. Carrot cultivation spread from France and Italy into other parts of Europe, and the crop had become a staple by the thirteenth century. They were introduced into China around AD 1300 and were widely grown there and in Japan, beginning in the sixteenth century.

Roots of early carrots were purple, and the yellow-orange color arose as a mutant. The Dutch further developed orange varieties in the 1600s. They entered the New World by 1565 and were grown in Virginia by 1609. By this time, the purple-roots were being superseded by those with yellow roots. Native Americans were fond of carrots, and Gen. John Sullivan reported them growing it in central New York in 1779.

Carrots entered into the modern folk culture of the Hebrides, where young women served them to special friends on Sundays. In Germany, finely chopped and browned roots were used as a substitute for coffee, and the English used red carrot juice to color butter. During World War II, British plant breeders developed high-carotene carrots for their aviators so that they might see better at night.

Plant carrot seeds thinly; you don't have to thin the plants. Thinning may promote nicer roots, but it will give you fewer useful roots. You can also avoid much thinning by making your own seed tape. Space seeds within a single fold of inexpensive toilet paper. Roll it up as you go to maintain seed spacing, and unroll in the garden. The tissue will decompose in place.

Suggested Carrot Varieties

Variety	Days to maturity	Comments
Purple Haze	73	2006 AAS Selection; Imperator type; orange interior with purple skin
Nelson	58	Orange Nantes type; early and nearly coreless
Scarlet Nantes	68	Heirloom; orange, very sweet; open-pollinated
Red Cored Chantenay	70	Heirloom; orange 6" roots; for heavy soil

Fresh manure applied to your carrot beds promotes forked roots, but rotted or composted manure is fine. Carrots should grow rapidly for the highest quality, so apply your preplant fertilizer and side-dress when the plants are about 4–5 weeks old.

Watering properly is important, for if the weather is hot and dry, the roots will develop a strong flavor. On the other hand, excessive moisture results in poor color development.

Carrot types are separated by their shapes. Nantes-type varieties produce cylindrical roots, while the Imperator type produces long, slightly tapering roots. The Chantenay type produces roots that are shaped nearly like a toy top and are most useful for growing on heavy or shallow soils.

Harvesting: Pull carrots when the roots are about 1–11/2" in diameter at the top. The upper part of the carrot "root" is made of stem tissue and turns green when exposed to sun. This won't hurt you, but it detracts from the root's eye appeal. Mound the soil over the crown of the root a couple of weeks before harvest to avoid this greening.

What Happened Here?

My carrot seeds produced a poor stand. The soil may have

crusted, or the seeds dried out before germination. Use a nurse crop with the carrot seeds next time.

Carrots have misshapen roots. Root twisting is due to overcrowding. Forked roots are likely caused by stony soil. If the roots are stubby or grew horizontally for a bit, you have a hardpan layer.

My carrot roots have lots of little roots and almost look hairy. This can be caused by the application of fresh, uncomposted manure during the season. It could also be a disease called “aster yellows.” It causes bronzing of foliage and witches-broom-type tops. Pull and discard if you see off-colored tops.

Remove the carrot tops before storing the roots as they pull water and nutrients out of the roots and lead to rapid deterioration.

Cauliflower

Brassica oleracea (Botrytis group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 60–65˚F
Minimum Soil Temperature for Planting: 45˚F
Transplant Spacing within Row: 14–24"
Days to Maturity: 50–125
Distance between Rows: 24–36"
Depth of Root System: Shallow
Ease of Transplant: Easy
Consumption of Nitrogen: Moderate to heavy
Average Yield per 10' Row: 9 lb. or about 6 curds

Grow Your Own Transplants
Optimum Range of Soil Temperature for Germination: 65–70˚F
Approximate Length of Germination Period: 3–4 days
Approximate Time to Grow to Transplant Size: 4–6 weeks

Like the other brassicas, cauliflower grows best in cool, moist weather and it will not tolerate as much cold or as much heat as cabbage. It grows best at temperatures between 57˚F and 68˚F. At temperatures above 68˚F, the quality of the curds deteriorates, and they become leafy. At temperatures above about 77˚F and below 32˚F, the curd may not form at all.

Planting and Care: Many Rocky Mountain gardeners agree that cauliflower is one of the trickiest of the brassicas to grow. But do try it and see how it does in your garden!

While cauliflower can be grown in our region as both a spring and a fall crop, it is grown mostly as a fall crop to avoid summer's heat. You can transplant young plants to the garden or direct seed. Space rows about 30" apart and thin the plants to stand about 14–24" apart in the rows.

These plants have high-fertility soil requirements and do best in fairly acid soils within the pH range of 5.5–6.5. Yields are reduced in soils with pH ranges much above or below this.

Fun Fact

Cauliflower evolved from sprouting broccoli and ultimately from the leafy cabbages of southern Europe and the eastern Mediterranean. While references to broccoli and cauliflower are confused in ancient literature as the same name, cyma, *was applied to both plants, cauliflower was considered a separate plant in eighteenth-century England.*

Turn under organic matter, broadcast preplant fertilizer, and side-dress the plants when they are several inches tall. Cauliflower has a high magnesium requirement, so take care to watch for

deficiencies of that nutrient. If plants receive too little nitrogen, they will “button,” forming small, inedible curds.

Cauliflower can develop several other nutrient deficiencies. Whiptail, due to a molybdenum deficiency, shows up when the soil pH is very acid (below 5.5). In our region this could result from amending garden soil with ore waste from mines (tailings). The leaves become straplike and extremely savoyed, and plant growth is stunted.

What Happened Here?

My cauliflower produced small heads. This could be uneven or insufficient watering, or, if they are very small (about the size of a quarter), the plant buttoned.

I have off-color curds. You waited too long to harvest and they became ricey.

My curd has leaves growing in it. Hot weather causes this. Time your planting so the curds ripen earlier or later in the season.

Browning, also known as brown rot or red rot, is caused by boron deficiency and shows as water-soaked areas in the stem and branches of the curd. The curds turn reddish brown and become inedible. The foliage thickens, becomes brittle, and curls downward. Have your soil tested for boron and follow the recommendations of the testing agency. Do not guess at the amount of boron to add, as too much can sterilize the soil.

Buttoning results in small, exposed curds. The plants and leaves are stunted. Crowding in the flat, nitrogen deficiency, and any other condition that restricts early growth can cause buttoning.

Blindness, the result of no terminal bud forming, is caused by physical damage to the tip.

Cauliflower curds may be white, green, or purple. The purple-curd types are actually hybrids of broccoli and cauliflower that develop the curd shape of cauliflower and the sweet tenderness of broccoli. Called “broccoflower,” they require no blanching and the color disappears when the curd is cooked. Another such hybrid produces plants with green curds.

To get a nice white curd, cauliflower must be protected from the

sun by blanching. The leaves of self-blanching varieties naturally curl over the curd and shut out the sunlight. You will have to blanch curds of the other white-curded varieties yourself, which is not at all difficult. Tie the outer leaves over the curd when it is a couple of inches in diameter and leave them for a few days before you harvest. Cooler fall weather may require you leave them for up to 10 days. Be sure to check curd development every day, for leaving them tied too long in hot weather can cause the leaves to rot, while in cool weather the curd will flower. Flowering turns the curd fuzzy and brownish gray due to the production of flower parts (stamens and anthers). This is called “riciness.” Instead of tying the leaves, you may break several outer leaves and arrange them over the curd. If you don’t want to do this but don’t want to take the time to tie the leaves either, try gathering several outer leaves over the curd and holding them in place with a toothpick. If that sounds like a lot of work, buy your cauliflower in the grocery.
Harvesting: Cut the blanched curd from the stem when it is about 6" in diameter. Trim the leaves square across the top and about 1/2" above the curd to protect it.

Suggested Cauliflower Varieties

Variety	Days to maturity	Comments
Early Snowball	60	Heirloom; white 6–7" curds
Snow Crown	50	1975 AAS Selection; White curded; good seedling vigor; medium-sized heads
Graffiti	80	Purple curds; medium vigor
Cheddar	58	Bright orange curds
Vitaverde	71	Lime green curds

Celeriac

Apium graveolens (Rapaceum group)
Family: Parsley / Apiaceae (formerly Umbelliferae)

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 60–65˚F
Minimum Soil Temperature for Planting: 45˚F
Transplant Spacing within Row: 4–6"
Days to Maturity: 100–120
Distance between Rows: 24–36"
Depth of Root System: Shallow
Ease of Transplant: Moderate
Consumption of Nitrogen: High
Average Yield per 10' Row: 6 lb.

Grow Your Own Transplants

Optimum Range of Soil Temperature for Germination: 70–75˚F
Approximate Length of Germination Period: 2–3 weeks
Approximate Time to Grow to Transplant Size: 10–12 weeks

Planting and Care: Grow celeriac as you would celery.

Fun Fact

Also known as turnip-rooted celery, celeriac is a type of celery grown for its celery-flavored tuberous root that grows to about the size of a fist.

Although celery roots were eaten before 1536, the first mention of celery grown for its root was in 1613. The plant likely arose in Mediterranean marshes but became highly developed among northern Europeans. It was grown in England in 1752 and made its way into American gardens by 1806.

Harvesting: Harvest when the roots are 3–5" in diameter. ‘Brilliant’ and ‘Mars’ are two good varieties.

Celery

Apium graveolens (Dulce group)
Family: Parsley / Apiaceae (formerly Umbelliferae)

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 60–65°F
Minimum Soil Temperature for Planting: 45°F
Transplant Spacing within Row: 6–12"
Days to Maturity: 90–125
Distance between Rows: 18–40"
Depth of Root System: Shallow
Ease of Transplant: Moderate
Consumption of Nitrogen: High
Average Yield per 10' Row: 10 heads

Grow Your Own Transplants
Optimum Range of Soil Temperature for Germination: 70–75°F
Approximate Length of Germination Period: 14–21 days
Approximate Time to Grow to Transplant Size: 10–12 weeks

Celery is a biennial grown as an annual, forming a short stem surrounded by leaf stalks (petioles) up to 2' tall.

The plant grows best at temperatures of 60–65°F, and young plants will bolt if exposed to temperatures of 40–50°F for more than 10 days. Temperatures in the 70s or higher while the plants are maturing turn the plants stringy and strong flavored.

Planting and Care: Celery is very exacting in its requirements. Because of its marshy origins it does well in a well-drained loam high in organic matter. Soil pH is best between 5.5 and 6.7, and the plant should grow rapidly to avoid stringiness.

Suggested Celery Varieties

Variety	Days to maturity	Comments
Conquistador	80	Widely adapted; very vigorous
Tango	80	Tender, less fibrous stalks; fusarium resistant
Utah 52-70R Improved	90	Compact 12" stalks

Transplant celery in the spring, moving plants to the garden when they are about 4–6" tall. Celery plants grown from transplants have even smaller root systems than those direct seeded, so you will have to take extra care in growing them.

Fun Fact

Homer mentioned celery in the Odyssey, *and Hippocrates, Theophrastus, and Pliny spoke of wild celery's medicinal properties. The ancient Greeks rewarded athletes with celery leaves, and the Romans seasoned foods with its seeds. It was widely used by Chinese doctors in the fifth century AD and is mentioned in a ninth century AD European work. At that time, it was still gathered wild from swamplands from Sweden to Algeria and east to India.*

Celery began to be used to flavor broths in the Middle Ages but was used almost exclusively for medicine through the early eighteenth century. Italians grew it by the end of the sixteenth century, and it had entered French gardens by 1623.

What Happened Here?

My plants are stunted and have yellow leaves. Because of the plant's small root system, this could have many causes:

hot weather, dry soil, low soil nutrients, too-deep cultivation.

Because celery plants are heavy feeders, broadcast preplant fertilizer and side-dress the plants a few times during the season. By doing this, we “push” their growth to promote development of the most tender stalks.

Keep the plants cultivated or mulched with straw always, and don’t let the weeds gain a foothold.

Because of its origins and small root system, celery needs relatively large quantities of water. Any water stress will result in poor growth and stringiness.

Several nutrient disorders can affect celery. Black heart is due to a calcium deficiency made worse by high temperatures, rapid growth, and water stress. The inner leaves and growing point die.

Cracked-stem causes a marginal brown mottling of leaves. The petioles become brittle and tissues turn brown due to a boron deficiency.

Pithiness is the result of too-rapid growth. The petiole cells break down, causing corky tissue and cavities.

There are 2 types of celery: golden and green. Golden celery is self-blanching and was formerly quite popular. These varieties mature earlier and are less vigorous, stringier, and have thinner petioles than those of the more common green type.

Harvesting: Because of the long season required to harvest fully mature celery plants, always select shorter-season varieties; however, there is no absolute harvest period. Cut the stalks at the soil line when they are large enough for your use. The outer petioles become stringy and tough if you wait too long to harvest.

Blanching produces golden, mild-flavored stalks. You can plant a self-blanching variety or blanch a green variety by covering the stalks several weeks before harvest. Crowding plants in the row will partially blanch the stalks.

Collards

Brassica oleracea (Acephala group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Either
Optimum Range of Soil Temperature for Germination: 45–95°F
Minimum Soil Temperature for Germination: 40°F
Optimum Range of Soil Temperature for Transplanting: 60–65°F
Minimum Soil Temperature for Transplanting: 40°F
Seed Planting Depth: 1/4–1/2"
Days to Maturity: 60–70
Seed Spacing within Row: 3 every 8"
Depth of Root System: Shallow
Thinned Spacing within Row: 8"
Consumption of Nitrogen: Moderate to high
Distance between Rows: 18–30"
Ease of Transplant: Easy
Average Yield per 10' Row: 71/2 lb.

Grow Your Own Transplants

Optimum Range of Soil Temperature for Indoor Germination: 65–70°
Approximate Length of Germination Period: 3–4 days
Approximate Time to Grow to Transplant Size: 4–6 weeks

Like many other vegetables, collards are biennials grown as annuals. They are a cool-season crop and are most popular in southern US gardens.

Fun Fact

Collards, a form of non-heading cabbage, were enjoyed by Greeks and Romans before a banquet with the thought that it kept the mind from being clouded by wine.

This plant tolerates both heat and cold better than cabbage (down to 15°F if acclimated) but is best grown as a spring or fall crop.

Planting and Care: You can direct seed for a fall crop or set out

transplants for a spring crop. Prepare the soil as for cabbage and grow collards as you would kale.

Suggested Collard Varieties

Variety	Days to maturity	Comments
Georgia Southern	60	Heirloom; tolerant of heat, cold, and poor soil
Flash	55	Smooth-leaf hybrid; slow bolting
Tiger Hybrid	55	Slightly savoyed leaf hybrid
Top Bunch	50	Slightly savoyed leaf hybrid; early

Harvesting: The greens are ready to harvest about 60 days after seeding. Harvest older, larger leaves; the bud will continue producing leaves as the stem elongates. After several weeks of harvest, the plant will resemble a tuft of new leaves stuck on a long stalk and may need to be staked. If you don’t care about multiple harvests, then harvest the entire plant when it is about 6–12" tall.

Corn, Sweet

Zea mays var. *saccharata*
Family: Grass / Poaceae (formerly Gramineae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 60–95˚F
Minimum Soil Temperature for Germination: 50˚F
Seed Planting Depth: 1/2–1"
Days to Maturity: 64–95
Seed Spacing within Row: 4–6"
Depth of Root System: Shallow
Thinned Spacing within Row: 8–12"
Consumption of Nitrogen: Heavy
Distance between Rows: 30–42"
Average Yield per 10' Row: 24 ears

Corn is a tropical and subtropical plant that does not grow in soil temperatures below 50˚F and grows very slowly at 60˚F and above 95˚F. The best soil temperatures for corn are between 70˚F and 85˚F. Corn does not grow well in hot nights, contrary to popular belief.

Nearly the entire stalk of a corn plant is telescoped back into the seedling; much of the plant's growth is simply elongation of the inter-nodes. Tasseling begins at the 7-leaf stage. Each tassel produces up to 50,000 pollen grains for each silk produced by the ear.

Each strand of silk (female flower) is attached to 1 kernel. Each cornstalk produces 1–3 ears and 1 tassel. The first ear forms in the middle of the stalk and will be the largest. After pollination, ears rapidly enlarge, collecting sugars from the leaves. The more leaves, the more sugar.

Flowering in corn is a function of day length. Long, hot days favor stalk growth, while short, cool days favor flowering and ear formation. Tropical varieties won't flower in temperate areas until day length shortens to about 12 hours. Northern varieties flower under long days and cooler temperatures, so select northern varieties for your garden.

Planting and Care: Corn seeds will not germinate in soil temperatures below 50˚F. At 55˚F, it takes about 3 weeks for the seeds to germinate (if they don't rot first); at 75˚F, only about 4 days.

Plant the seeds in short blocks with rows spaced 3' apart to aid pollination. Thin plants when they are about 5" tall to stand 10" apart. Overcrowded plants produce small ears with poor tip fill.

If you have room, plant early-, midseason-, and late-ripening varieties at the same time, or make successive plantings of the same variety about 10 days apart to extend the harvest season.

Corn has a shallow, fibrous root system and is moderately tolerant of soils with higher pH as long as the soils are fertile. Broadcast preplant fertilizer, and improve the soil with large amounts of organic material. Side-dress your corn at least once during the season, especially if the lower leaves begin to yellow.

Fun Fact

Corn is one of the few native American vegetables. The plant grew in

Mexico at least 80,000 years ago and was cultivated in southern Mexico at least seven centuries ago. Ancestors of our modern type had a tassel at the tip of each ear. On his return voyage in 1493, Columbus brought corn to Europe where it was called "turkey corn." The corn of historical record is the dent corn (also called "cow corn" or "field corn"), grown for feed and meal. Lt. Richard Bagnal, a member of General Sullivan's 1779 expedition against the Six Nations, found the Iroquois raising sweet corn and brought some back to New England. It immediately was accepted and, by 1820, had become a major crop. Sweet corn is a mutant "cow" corn wherein the conversion of sugar to starch is retarded. Until the twentieth century people preferred white corn, feeling that yellow corn was fit only for animal feed.

Corn doesn't tolerate flooding or drought. Drought will stunt the stalks, rot the silk, and ears will be poorly filled and stubby. If corn leaves are tightly rolled, you'd better water right away.

There are huge numbers of sweet corn varieties available, and they are white, yellow, or bicolor. Most of these are hybrids selected for increased pest resistance and sugar content. Many of the types have confusing names. Some types are constantly changing, and various catalogs use different systems. Here is a small sampling.

Sugary ("su," "normal," "traditional," "sugar," and "standard"): This is the standard sweet corn we knew in the old days. It contains 10–15 percent sugar and has a creamy texture. The sugar turns into starch rapidly during maturation, and the corn goes downhill fast.

Sugary-enhanced ("se, "su se," or "se+"): This corn has twice as much sugar as those in the sugary class, and kernels have the same creamy texture. Although the sugar converts to starch at the same rate as in the sugary class, this corn has more to begin with, so it remains sweeter longer.

Shrunken-2 ("sh2," "supersweets," and "extrasweets"): These develop 2 to 3 times more sugar than the "su" type, which is converted to starch more slowly. Because of its lower starch content, the kernels have a crunchy rather than creamy texture. Further, seeds germinate poorly in cool soil and under water stress. Plant them later than the se or su types. These varieties usually don't yield as much as the su and se varieties, and some folks find this corn far too sweet.

Suggested Sweet Corn Varieties

Variety	Days to maturity	Comments
Spring Treat	66	se; yellow; very early; good in cold soil
Sugar Buns	70	se+; yellow; long harvest; for latitude 38°N and higher
Bodacious	75	se; yellow; 8" ears
Quickie	64	se; bicolor; short plants
Double Standard	73	Open-pollinated bicolor; plant only white kernels for all white
Early Sunglow	63	su; heirloom; yellow; 7" ears
Butter and Sugar	73	su; bicolor; 7" ears
Northern Xtra Sweet	67	sh2; available yellow or bicolor; 8" ears
Xtra-Tender 2171	71	sh2; bicolor; good cool-soil vigor

Synergistic: Made of 75 percent se kernels and 25 percent sh2 kernels, these combine the increased sugar content of the sh2 supersweets with the tenderness of the se sugary-enhanced types.

Now, which type is right for you? If you have a sweet tooth, choose one of the sweeter types. If you like the old-fashioned creamy taste, stick with the sugary class. But remember, sweet corns cross-pollinate, and that could spell trouble. A supersweet pollinated by a sugary variety will become “normal.” So, isolate the supersweet (sh2) varieties from all other types. Follow these rules.

1. For most classes, you may plant different varieties of the same type near each other without influencing the sugar content.
2. Isolate varieties of supersweet and synergistic types since cross-pollination will make their kernels starchy. Pollen from these makes kernels of the sugary and sugary-enhanced starchy, too.
3. Different-colored corns can cross-pollinate. Pollen from a yellow variety landing on the silks of a white variety will cause the kernels to which those silks are attached to become yellow. If it lands on silks of a bicolor, it will increase the number of yellow kernels. Pollen from a white variety will not change the color of kernels. To be sure, isolate varieties by at least 250' or plant them to ripen at least 14 days apart. Some folks with limited space have success isolating different types by planting tall crops between them, like sunflowers.

In addition to a number of diseases, sweet corn is troubled by a couple of physiological disorders.

Poor tip fill results from poor pollination. Hot winds, temperatures above 96°F, and drought stress interfere with pollination.

Shriveled kernels near the tip indicate a lack of nitrogen.

As corn matures from the edible “milk” stage (about 20 days after pollination) to the dry “dent” stage, sugar converts to starch and quality decreases. Examine the corn about 20 days after silking. Silks will have begun to dry and the kernels will feel plump. Crush a kernel with your finger. If clear liquid comes out and the kernels are small, the corn is in the immature “premilk” stage. If “milk” (starchy semiliquid) squirts out, the ear has reached prime eating quality.

What Happened Here?

I get very few good ears of corn. You may have had poor pollination. Plant corn in small blocks and remember that you’ll only get a couple of ears on each stalk anyway unless you plant ‘Six Shooter’, which requires a long season.

The kernels at the tips of the ears do not develop. Poor tip fill is usually caused by poor pollination and/or bad weather during silking.

My corn seedlings are all lying on top of the soil, and the seeds are missing. Birds probably pulled out the seedlings to get to the seed. Get a cat, or place wire fencing over the seedlings, but remember the problem disappears as they grow.

My corn produces little ears in the tassel and little tassels in the ear. Climatic stress, such as long, cool springs following early periods of warm weather, produces these abnormalities.

How do I control earwigs in my corn silk? They really aren’t damaging your corn. Pull the husks off the ears outside.

Corn passes from the milk stage into the starchy “early dough” stage in less than a week. You can still eat it in this stage, but it is noticeably less sweet and much more pasty. When it has reached

the “dough” stage, it’s ready for the chicken yard.

Harvest the ears by snapping them from the stalk and cool them to 32°F immediately by plunging them into ice water. The best way to eat corn is to have the pot boiling when you pick it.

Cucumber

Cucumis sativus
Family: Gourd / Cucurbitaceae

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 60–95˚F
Minimum Soil Temperature for Germination: 60˚F
Seed Planting Depth: 1/2"
Days to Maturity: 48–72 (slicing): 48–58 (pickling)
Seed Spacing within Row: 3–4"
Thinned Spacing within Row: 8–12"
Depth of Root System: Moderate
Distance between Rows: 36–72"
Consumption of Nitrogen: Moderate
Average Yield per 10' Row: 12 lb.

Cucumber grows best in air temperatures between 65˚F and 85˚F, with 82˚F considered ideal. Growth declines substantially in temperatures above 90˚F and below 60˚F. The plant chills and dies at temperatures below 50˚F.

A moderately deep-rooted annual vine, the cucumber has 1 of 3 growth habits. *Indeterminate* varieties form new shoots that extend the entire season, making a sprawling plant. A flower cluster forms at the vine tips on *determinate* varieties and stops their extension. *Compact* varieties are bushy and well suited to small gardens.

Standard cucumbers have male and female flowers on the same plant (*monoecious*). Male flowers bloom first. Early in the season, on hot, long days, or under stress any time, you'll have more male flowers than female. As the season advances, and the days become shorter and cooler, male and female flowers appear in about equal numbers.

Many cucumber varieties ("PF," or predominately female) produce more female flowers than male. *Gynoecious* lines produce only female flowers. These varieties ripen all their fruit nearly at once. Since there are no male flowers in gynoecious varieties, seed producers include in the packet a few seeds of a monoecious variety for plants that bear male flowers for pollination. Be sure to plant those seeds!

Planting and Care: Soil temperatures of at least 65˚F are needed for good cucumber plant growth, though 85˚F is optimum. Plant your seeds about 1–11/2' apart in rows spaced 4' apart. Or, plant in hills about 3–4' apart, dropping several seeds into each and thinning the seedlings to 2 plants per hill. You can also transplant 4-week-to the garden.

Fun Fact

The cucumber may have originated in Southeast Asia at least 12,000 years ago. It has been grown for its fruit for at least 3,000 years and passed from India into Greece and Rome, and more recently into China. Romans raised them in greenhouses in winter. Roman emperors imported cucumber pickles from Spain, and traders spread the plant throughout Europe. It was grown in France in the ninth century and in England in the fourteenth; it was introduced into North America by the middle of the sixteenth century. The Spanish explorer Hernando de Soto reported the natives in Florida growing cucumbers "better than those found in Spain."

What Happened Here?

My cucumber fruit are misshapen and drop from the plant before harvest. This could be due to poor pollination.

My cucumbers are bitter. My neighbor told me that's because I planted carrots nearby. Is that true? Bitterness in cucumbers is caused by compounds known as cucurbitacins, which accumulate in temperatures above 90°F and in abnormally cool, wet weather. Bitterness has nothing to do with carrots.

We returned from vacation and our cucumber plants had only a few big yellow fruit on them and stopped producing. Vacation at a different time next year. Cucumber fruit that ripen on the vine shut down the production of new fruit. Keep picking the fruit as they enlarge and the plant will keep producing.

Plant cucumbers on the edge of your garden and let them sprawl onto the grass or train them to a trellis. Broadcast preplant fertilizer and side-dress once, just as the plants begin to run. They respond well to manure so place a handful or two into each hill at planting if you have it.

Cucumbers need large amounts of water in hot weather, especially during bloom and fruiting.

Black plastic mulch will increase yields substantially. Organic mulches are also fine but don't apply them until the soil has warmed.

Cultivate shallowly and often until the plants begin to run.

Cucumbers come in slicing and pickling types. Slicers are generally long, slender, straight, thick-skinned, and dark green. Their relatively large seed cavities make them soft if pickled. Picklers have smaller seed cavities that stay firm during the pickling process. They are light green, short, blocky, thin-skinned and warty; most newer pickling varieties are gynoecious.

Suggested Cucumber Varieties

Variety	Days to maturity	Comments
Straight Eight	58	1935 AAS Selection; heirloom; monoecious slicer; 6–8" fruit
Sweet Slice	62	Monoecious slicer; 10–12" fruit; burpless
Early Pride	55	Slicer; 8½" fruit
Olympian	52	Gynoecious slicer; 6–9" fruit
Pickalot	54	Pickler; bush
Boston Pickling	50	Heirloom; vigorous; open-pollinated
Lemon	65	Heirloom; 3–4" round fruit are lemon yellow; fresh or pickling

Harvesting: Depending on the variety, harvest begins about 60 days after planting. Pick the fruit while it's still green and several inches long (slicers) or 2–4" long (picklers). Never let cucumbers ripen and yellow on the vine. These will be seedy and will signal the plant to stop flowering and producing new fruit. If you can't use them all when they're ready, donate them to a food bank.

Eggplant

Solanum melongena
Family: Potato or nightshade / Solanaceae

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 70–85°F
Minimum Soil Temperature for Planting: 66°F
Transplant Spacing within Row: 18–30"
Days to Maturity: 50–80
Distance between Rows: 24–48"
Depth of Root System: Moderate
Ease of Transplant: Moderate
Consumption of Nitrogen: Heavy
Average Yield per 10' Row: 7½ lb.

Grow Your Own Transplants
Optimum Range of Soil Temperature for Germination: 80–90°F
Approximate Length of Germination Period: 7–14 days
Approximate Time to Grow to Transplant Size: 8 weeks

This very tender plant requires a long growing season of 100–140 days because it is killed by light frosts and injured by long periods of chilly weather. Fruit set is poor below 65°F, and growth ceases below 63°F. Temperatures below 61°F deform the pollen, producing misshapen fruit. Any slight check in growth decreases fruit quality. The plant makes its best growth and has highest fruit quality when daytime temperatures remain between 80°F and 85°F and nighttime temperatures hover about 70°F.

Typical eggplants are 2–8" in diameter; Asian types are smaller. Fruit color may be purple, yellow, white, green, red, or black, with purple and black being the most common.

Planting and Care: Set nonhardened, blocky, 7"-tall plants in the garden about 2 weeks after the danger of frost has passed and when daytime temperatures average about 68°F. A cool snap after planting can stunt the plants, and, once stunted, they will seldom resume satisfactory growth.

Spreading preplant fertilizer will get the plants off to a quick start, but eggplant is a heavy feeder. It responds well to soils high in organic matter, so mix some rotted manure into the hole at planting and side-dress the plants lightly when growth resumes after transplanting. A small handful of 10-10-10 fertilizer or nitrogen equivalent spread in a broad band about 1' from the base of each plant will do it. Side-dress every 6 weeks throughout the season.

Water stress during flowering can reduce yields substantially and

lack of water during fruit maturity will mean a lot of blossom-end rot.

Eggplants don't need staking unless they have a heavy fruit load or you have windy weather.

Eggplant flowering begins after the 6th leaf has opened on early varieties and the 14th leaf on late varieties. Spiny, star-shaped, purple flowers give rise to large fruit at temperatures above 65°F.

The most common varieties bear large, purple, oval-shaped fruit that mature 70–80 days after transplanting, although the smaller Asian varieties mature much earlier.

Eggplants can be divided into different types.

Snake Eggplant: Fruit of this distinct botanical variety average about 1" in diameter but grow to lengths of about 15".

Dwarf Eggplant: This type produces small, weak plants and small, pear-shaped purple fruit that matures quickly.

Fun Fact

The common eggplant probably originated in India and Burma (now called Myanmar) while smaller-fruited varieties, such as the snake eggplant, the dwarf eggplant, and the Asian eggplants, probably originated in China. The plant was in China as early as the fifth century BC. Moors introduced the plant into Spain in the seventh century AD. Arabs and Persians brought it to Africa before the Middle Ages, and from there it entered Italy in the fourteenth century. Spanish explorers brought purple- and white-fruited varieties with them to the New World. They were grown in Brazil in 1658. Early New Englanders considered the fruit poisonous, and prior to the twentieth century American gardeners grew the plants mostly as ornamentals.

Asian types: These produce small, usually elongated, slender fruit that is very ornamental.

In addition to getting its share of diseases and insects, the eggplant is also susceptible to blossom-end rot brought on by uneven moisture availability or by moisture stress. For further information, see the discussion of this disorder under the tomato entry.

Most varieties need 2–3 months to mature their fruit, but fruit can be eaten from the time it is about ⅓ grown. Don't eat really immature eggplant because they contain the poisonous alkaloid solanine, the same compound found in the skin of green potatoes.

Harvesting: Fruit ready for harvest are firm and glossy. Overmature fruits become spongy, seedy, and dull, and their seeds darken. To determine if your fruits are ready for harvest, look at their sheen and color, and press your thumb into their side. If the indentation springs back, the fruit is immature; the depression remains in the flesh of mature fruit. Because the fruit bruises easily, don't use the thumb test on all of them, but reserve it for those you believe are probably ripe anyway. Continue to harvest the fruits as soon as they are ready, and the plant will continue to bear until frost. Cut eggplants from the plant with pruning shears, leaving about 1" of stem and the calyx, or "cap," attached to the fruit.

What Happened Here?

The leaves of my eggplants have tiny holes in them. This is undoubtedly flea beetle damage. See the section in chapter 10 on pests.

My eggplants plants wilted and died. Assuming you watered well and didn't hoe too deeply, you might have Verticillium wilt. Destroy affected plants and use a 4- or 5-year rotation.

I transplanted my eggplants to the garden early and they just sat there. Eggplants need a warm growing season. If they experienced temperatures below about 60°F, their growth may have stopped.

Suggested Eggplant Varieties

Variety	Days to maturity	Comments
Black Beauty	74	Heirloom; large fruit
Purple Rain	66	Heavy yields; large fruit
Crescent Moon	62	White fruit; delicate flavor
Ichiban	55	Asian type; long, slender purple fruit
Fairy Tale	50	2005 AAS Selection; miniature purple striped fruit; heavy yields
Millionaire	55	Asian type; heavy yields of slender purple fruit

The fruit of eggplant deteriorates rapidly at warm temperatures and suffers chilling injury below 50°F. Once warmed, chilled eggplants appear pitted, their surface is bronze colored, their seeds are brown, and they rot rapidly.

Endive

Cichorium endivia
Family: Sunflower / Asteraceae (formerly Compositae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 45–95°F
Minimum Soil Temperature for Germination: About 40°F
Optimum Range of Soil Temperature for Best Growth: 55–75°F
Minimum Soil Temperature for Best Growth: 45°F
Seed Planting Depth: ¼"
Days to Maturity: 90
Seed Spacing within Row: 3"
Depth of Root System: Moderate
Thinned Spacing within Row: 8"
Consumption of Nitrogen: Low
Distance between Rows: 18–24"
Average Yield per 10' Row: About 5 lb.

Endive is a loose-headed plant with frilly leaves, while escarole is simply a marketing term for broad-leaved endive. Both belong to the same species (*Cichorium endivia).* New red varieties are being developed, and both are used in salads or as potherbs.

Endive and escarole are cool-season plants grown as annuals. They withstand cool weather better than lettuce but do not stand heat quite as well.

Endive must grow rapidly for best quality, growing best at temperatures between 60°F and 75°F; it will bolt under long days and high temperatures.

Fun Fact

This lettuce-like plant originated in eastern India and was used for food by the ancient Egyptians before it spread into northern Europe at the time of the Crusades. There it was used medicinally and finally as food in the fourteenth century.

Planting and Care: Sow endive seeds right in the garden in rows about 18" apart and thin the plants to stand about 10" apart in the row, or transplant them to the garden in spring. Both are sown to

mature in fall because of their long maturity season and their ability to tolerate low temperatures.

The leaves become yellow white and develop milder flavor if they are blanched, formerly a common practice that has fallen by the wayside in recent years. Do this by crowding them in the row, by tying the outer leaves over the head as you would blanch cauliflower (see that entry), or by placing tar paper or boards over the plants for 1–2 weeks before harvest.

Suggested Endive and Escarole Varieties

Variety	Days to maturity	Comments
Clodia	33+	Endive; very early
Salad King	95	Heirloom; endive; slow bolting; very fancy, curly leaves
Eros	46	Escarole; dense heads
Full Heart	90	1934 AAS Selection; heirloom; escarole; tolerant to bolting and tipburn

Harvesting: If you want full-sized heads, harvest when they are well developed. Cut the entire plant at the soil line and remove outer leaves, which are often tough and bitter.

What Happened Here?

My endive plants formed flower stalks. The temperature got too high.

The bottom leaves of my endive are chewed. Undoubtedly due to slugs. If you see silvery slime trails, set out the boards to lure them under the cool cover, then collect and squish. Or set out saucers of beer for them to crawl into and drown.

Garlic

Allium spp.
Family: Amaryllis / Amaryllidaceae (formerly Alliaceae)

Direct Seed or Transplant: Plant cloves
Optimum Range of Soil Temperature for Growth: 55–75˚F
Minimum Soil Temperature for Growth: 45˚F
Seed Planting Depth: 1½–2"
Months to Maturity: 6–10 (variable)
Seed Spacing within Row: 4–6"
Depth of Root System: Shallow
Thinned Spacing within Row: 4–6"
Consumption of Nitrogen: High
Distance between Rows: 12–24"
Average Yield per 10' Row: 40–60 bulbs

The garlic bulb is a compound of small bulblets, or cloves, each having 2 mature leaves and a vegetative bud.
Planting and Care: Plant garlic in the very early spring where your springs are long enough, but where springs are short, it will perform better as a fall-planted crop to be harvested the following summer. It survives cold winters if covered by snow but will not take the summer heat, forming no bulbs at temperatures above 77˚F. Be sure the soil is friable and rich; heavy soils cause irregularly shaped bulbs.

Fun Fact

A native of southern Europe, garlic has been grown for at least 5,000 years. It had become an important Egyptian crop by 3200 BC, and the laborers building the Cheops pyramid about 2900 BC survived mostly on garlic and onions. They even went on strike when garlic rations were reduced. Homer mentions garlic in The Iliad. *Although Roman and Greek nobles did not prefer it, they offered it to their laborers and soldiers to give them strength and courage; Roman gladiators ate garlic before battle. From China and India it had spread by 500 BC throughout Asia. Cortez introduced garlic into North America in the early 1500s.*

Store bulbs at 40–50°F for several months before spring planting to break their dormancy. This is not necessary for fall planting as dormancy requirements are fulfilled over the winter. Plant as early in spring as the ground can be worked or in fall between September 15 and October 15. Later planting can increase the number of deformed bulbs.

What Happened Here?

My garlic plants grow weakly and don't produce good bulbs. You may not have fertilized or watered enough, or you may have planted too late.

My garlic bulbs are lopsided. Your soil may be too heavy or you did not space cloves far enough apart.

Garlic did not come up. You may have planted the cloves root end up. Garlic will not "right" itself if it's planted upside down.

Suggested Garlic Varieties

Variety	Comments
New York White (Polish White)	Softneck
Elephant	Elephant
German Extra-Hardy	Stiffneck
Chesnok	Heirloom; stiffneck
Inchelium	Heirloom; softneck

Separate the cloves just before planting, set them into the soil, root end down, and care for them as you would for onions. Plant the larger cloves and use the smaller ones for cooking since small cloves form plants that produce small bulbs. Water well as dry soil reduces bulb size.

Harvesting: There are three types of garlic: stiffneck, softneck, and elephant. Each type shows its own signs of when harvest should commence:

Stiffneck garlic (*Allium sativum*) sometimes called Rocambole, produces a woody scape (seedstalk) that resembles a pig's tail or corkscrew. Remove most of these to increase bulb size, and leave them on a couple of plants as harvest indicators. When the scape straightens, the plants are ready for harvest. This type generally produces smaller bulbs with nicely arranged small cloves compared to the softneck type. The cloves have milder flavor than those of softneck, and the plants are more cold hardy.

Softneck garlic (*A. sativum*) produces no woody scape, and its tops are easily braided for decorative purposes. It is ready for harvest when most of the bottom leaves have browned. This type produces larger bulbs than the stiffneck type, with stronger-flavored cloves.

Elephant garlic (*A. ampeloprasum* var. *ampeloprasum*) produces very large bulbs up to ½ pound each when given very fertile conditions. Cloves have milder flavor than those of the other garlic types. The plants are somewhat less winter hardy and the bulbs do not store as well as those of stiffneck or softneck types. Like the softneck varieties, harvest when the lower leaves have browned.

For all types, lift carefully with a spading fork and cure them by letting the entire plants dry in a cool, airy spot removed from direct sunlight. When the plants have dried and the leaves have turned papery, cut off the bulb, leaving about ½" of stem attached.

Gourd

Cucurbita, Lagenaria, and *Luffa* spp.
Family: Gourd / Cucurbitaceae

Direct Seed or Transplant: Either
Optimum Range of Soil Temperature for Germination: 70–95°F
Minimum Soil Temperature for Germination: 60°F
Optimum Range of Soil Temperature for Planting: 65–75°F
Minimum Soil Temperature for Planting: 50°F
Seed Planting Depth: ½–1"
Days to Maturity: 85–110
Seed Spacing within Row: 12" (plants); 48" (hills)
Depth of Root System: Deep
Consumption of Nitrogen: Heavy
Thinned Spacing within Row: 24–36"
Average Yield per 10' Row: Variable
Distance between Rows: 84–120"

Grow Your Own Transplants

Optimum Soil Temperature for Germination: 90°F
Approximate Length of Germination Period: 6–10 days
Approximate Time to Grow to Transplant Size: 4–5 weeks

Gourds have cultural requirements similar to those of pumpkins. They are very frost tender and will not grow at all below 60°F.
Planting and Care: Gourds can be direct seeded or transplanted about 3' apart in rows 7' apart. Training them to a trellis allows the fruit to hang freely and to maintain their shape. Support the larger fruit in onion bags or old brassieres.

Fun Fact

Gourds belong to several genera grown for their ornamental, novelty, or utility value. Most originated in tropical and subtropical America and were widely distributed before Columbus. The Luffa *genus originated in tropical Asia. While many gourds have edible flesh, their original use was as ladles, spoons, and water jugs.*

Gourds in the *Cucurbita* genus have thick shells and are difficult to cure. Their color fades after 3–4 months. ‘Apple’, ‘Crown of Thorns’, and ‘Spoon’ are some popular varieties. ‘Turks Turban’ is also a gourd in this genus, but it is sometimes listed as a winter squash. Varieties in the *Lagenaria* genus, such as ‘Calabash’, ‘Drum’, and ‘Swan Gourd’, make the best dippers, birdhouses, and rattles.
Harvesting: *Luffa*, also called “vegetable sponge” and “dishrag gourd,” is grown for its network of fruit fibers that serves as a sponge. Place the fruit in a tub or sink under running water and peel them like an orange. Squeeze the inner core to remove the seeds and flesh, and dry the remaining wad of fibers.

You can also harvest immature *Lagenaria* fruits about a week after bloom and eat them like summer squash. Or, after a light frost, harvest them when the fruit rind hardens, the fruit feels light, and the tendril next to the fruit stem browns. Cure them for 6 months in a warm, dry room.

What Happened Here?

I have lush, healthy-looking gourd vines, but few fruit. This is probably poor pollination from lack of bees or from poor weather during bloom. Remember that male flowers appear first and will not produce fruits.

My gourd vines grow well and then suddenly wilt. Look for a hole filled with sawdust-like material in the stem where the plant leaves the ground. Slit the stem lengthwise, passing through the hole and the small worm that made it.

Harvest fruit of *Cucurbita* species when a light frost has killed the vine and the fruit are bright and hard. Cure them for several days in warm, dry shade.

Kale

Brassica oleracea (Acephala group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Either
Optimum Range of Soil Temperature for Germination: 45–75°F
Minimum Soil Temperature for Germination: 40°F
Optimum Range of Soil Temperature for Planting: 60–65°F
Minimum Soil Temperature for Planting: 40°F
Seed Planting Depth: ¼–½"
Days to Maturity: 60–70
Seed Spacing within Row: 3 every 8"
Depth of Root System: Shallow
Thinned Spacing within Row: 8"
Consumption of Nitrogen: Moderate to high
Distance between Rows: 18–30"
Ease of Transplant: Easy
Average Yield per 10' Row: 7½ lb.

Grow Your Own Transplants
Optimum Range of Soil Temperature for Indoor Germination: 65–70°F
Approximate Length of Germination Period: 3–4 days
Approximate Time to Grow to Transplant Size: 4–6 weeks

There are 3 types of kale grown in the United States. Scotch kale, with its much-curled, crumpled leaves, and Siberian kale, with its frilly-edged smooth leaves, are both grown as edibles. Each type has dwarf and tall forms; the dwarf is more popular. The bicolor type is an ornamental landscape plant. Although it is also edible, we won't discuss it here.

Fun Fact

This is a winter-hardy, non-heading cabbage that is winter-killed only in very cold weather. Kale was well known to the ancient Greeks, and Romans grew several varieties by 200 BC. Kale was first noted growing in the New World (in Haiti) in 1565 and was found in Virginia gardens by the early 1600s.

Planting and Care: Transplant kale to the garden in early spring or direct seed it later in summer. Light freezes in late fall improve the quality of the leaves. Do not plant kale to mature in summer heat.

Kale is a heavy feeder so broadcast preplant fertilizer and side-dress when the plants are about a month old. Turn in plenty of manure and compost in the kale bed. Push the plants with water and nitrogen and the leaves will be succulent.

What Happened Here?

My kale is growing very slowly. It may be too hot or the soil may lack water or nutrients, particularly nitrogen.

My kale is bitter and strong flavored. It's too hot or the kale is too mature. A few light frosts will mellow its flavor.

Suggested Kale Varieties

Variety	Days to maturity	Comments
Dwarf Blue Curled Vates	55	Heirloom; finely curled leaves; plants 15" tall
Red Russian	50	Heirloom; purple stems; gray-green leaves with purple veins
Winterbor	60	Standard; very curly blue-green leaves
Lacinato (dinosaur or Tuscan kale)	60	Heirloom; blue-green crinkled leaves

Harvesting: Harvest the plants before their leaves become tough, or about 40–50 days after seeding. You can cut the entire plant or simply remove the older, outer leaves, leaving the inner ones to continue to grow.

Kohlrabi

Brassica oleracea (Gongylodes group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Either
Optimum Range of Soil Temperature for Germination: 65–70˚F
Minimum Soil Temperature for Germination: 35˚F
Optimum Range of Soil Temperature for Planting: 60–65˚F
Minimum Soil Temperature for Planting: 40˚F
Seed Planting Depth: ¼"
Days to Maturity: 50–60
Seed Spacing within Row: ½–1"
Depth of Root System: Shallow
Thinned Spacing within Row: 3–6"
Consumption of Nitrogen: Moderate to high
Distance between Rows: 12–36"
Ease of Transplant: Easy
Average Yield per 10' Row: 5 lb.

Grow your own transplants:
Optimum Range of Soil Temperature for Germination: 65–70˚F
Approximate Length of Germination Period: 3–4 days
Approximate Time to Grow to Transplant Size: 4–6 weeks

This plant is strange. It looks odd, and it’s a cool-season crop, developed in northern Europe, that is sensitive to cold. It bolts in temperatures below 45˚F and grows best at 60–70˚F.

Fun Fact

Kohlrabi is grown for its turnip-like swollen stem. It was first definitively described in Italy in 1554; it was introduced from Germany or Greece, where it may have evolved from marrow-stem kale. It was cultivated throughout continental Europe by 1570 and in Libya in 1573. It was first grown in Ireland as a field crop for both human food and stock feed by 1734 and was being grown in England in 1837. It was planted in American gardens by 1800.

What Happened Here?

My kohlrabi plants wilt and some turn yellow a few weeks

after transplanting. Pull up a plant or 2 and look at the roots. If root maggots are present, side roots will be absent, and you'll find the tiny maggots burrowing into the stem. Rotate your crop next year and protect the transplants with row covers or small pieces of tar paper placed on the soil around the plants' stems.

Kohlrabi plants are weak and yellow but have no root maggots. If the main root is malformed, then clubroot may be the problem. Rotate your crop next year and be sure to plant only treated kohlrabi seeds.

Are the pretty white butterflies around my kohlrabi eating holes in the leaves? Cabbage worms are very destructive to all brassicas. Use row covers to prevent the adult butterflies from laying their eggs.

Suggested Kohlrabi Varieties

Variety	Days to maturity	Comments
Eder	38	Very early; white skin
Early White Vienna	50	Heirloom; pale green skin
Early Purple Vienna	55	Purple skin; slightly larger than Early White Vienna

Planting and Care: Most gardeners direct seed this for a fall harvest. For a spring crop, start the plants indoors as you would cabbage or in a hotbed and transplant them to the garden when the soil warms.

Prepare the soil as you would for cabbage and give this plant the same care.

Harvesting: Pull your plants when the swollen stem is about 2–3" in diameter, since larger stems are woody and strong-flavored and likely cracked. Trim the leaves and the woody taproot.

Leek

Allium ampeloprasum var. *porrum*
Family: Amaryllis / Amaryllidaceae (formerly Alliaceae)

Direct Seed or Transplant: Either
Optimum Range of Soil Temperature for Germination: 70–75˚F
Minimum Soil Temperature for Germination: 35˚F
Optimum Range of Soil Temperature for Planting: 55–75˚F
Minimum Soil Temperature for Planting: 45˚F
Seed Planting Depth: ¼"
Days to Maturity: 75–120
Seed Spacing within Row: 2–6"
Depth of Root System: Shallow
Thinned Spacing within Row: 6"
Consumption of Nitrogen: Moderate
Distance between Rows: 12–36"
Average Yield per 10' Row: 20 plants
Ease of Transplant: Easy

Grow Your Own Transplants
Optimum Range of Soil Temperature for Germination: 70–75˚F
Approximate Length of Germination Period: 10 days
Approximate Time to Grow to Transplant Size: 9 weeks

Leeks are non-bulbing alliums grown for their basal leaves. They have a more delicate flavor than onions and are prized in cooking.

Fun Fact

The leek is an ancient plant; the Israelites complained to Moses that they had none to eat. Nero ate leek soup daily, claiming it strengthened his voice and, hence, gaining him the nickname "Leek Mouth." The plants were esteemed by the Welsh, who won a sixth-century AD battle over the Saxons by wearing leeks in their caps, by order of Saint David, to distinguish them from the enemy. The plants were popular in broths throughout the Middle Ages.

Planting and Care: Leek plants are often started in hotbeds or cold frames, transplanted in early spring, and given the same care as onions. Hill the soil around their bases to blanch the lower portions as the plants grow through the season, beginning when they are several inches tall.

What Happened Here?

My leeks rotted after I hilled them. You may have hilled them too soon or too deeply. Leave the soil loosely mounded over the lower parts of the leeks; do not firm.

Harvesting: Harvest the plants by pulling or using a spading fork when they are at least ½" in diameter at their base and have 4–6" of blanched stem.

Suggested Leek Varieties

Variety	Days to maturity (from transplant)	Comments
King Richard	75	12" white stems
Giant Musselburgh	80	Heirloom; 9–15" tall and 2" diameter
Lancelot	70	Bolt resistant; 14" stems

Lettuce

Lactuca sativa
Family: Sunflower / Asteraceae (formerly Compositae)

Direct Seed or Transplant: Either
Optimum Range of Soil Temperature for Germination: 40–80˚F
Minimum Soil Temperature for Germination: 35˚F
Optimum Range of Soil Temperature for Planting: 60–76˚F
Minimum Soil Temperature for Planting: 45˚F
Seed Planting Depth: Less than ¼"
Days to Maturity: 40–50
Seed Spacing within Row: Sow thinly
Depth of Root System: Shallow
Thinned Spacing within Row: 8–12"
Consumption of Nitrogen: Medium
Distance between Rows: 12–24"
Average Yield per 10' Row: 5 lb.
Ease of Transplant: Easy

Grow Your Own Transplants
Optimum Range of Soil Temperature for Germination: 40–80˚F
Approximate Length of Germination Period: 4–10 days
Approximate Time to Grow to Transplant Size: 3–4 weeks

Four types of lettuce are commonly grown in America: looseleaf (bunching), crisphead (iceberg), butterhead (Boston, bibb), and cos (romaine). Looseleaf is a short-season lettuce. It's easiest to grow and the most popular in our gardens. Crisphead is popular in markets but the most difficult to grow because of its long season and heat sensitivity. Butterhead is a semi-heading lettuce. Cos forms a long, upright plant more tolerant of weather than other heading types. There are myriad lettuce varieties available. Plant one of the tried-and-true varieties for a sure crop and allow yourself the fun of experimenting with others. An attractive salad includes a mix of lettuces including green, red, smooth, and frilly varieties!

Fun Fact

This Mediterranean and Asia Minor native was cultivated for food by the Egyptians at least 7,000 years ago. Before that, oil extracted from the seeds was used medicinally. Lettuce was served to Persian kings by the

sixth century BC. Dozens of varieties of lettuce were grown by the Romans; one particularly popular type was romaine (also known as cos). Emperor Augustus had a monument erected to the plant because he thought eating lettuce had helped him recover from illness. It was grown in China by the fifth century AD and was brought to the New World by Columbus on his second voyage. Leaf lettuce was the original type; head lettuce was not developed until after the discovery of the New World. A "Puerto Rican" type arose from seeds brought to the New World by Columbus and became popular with the first American colonists. Both head and leaf types have been popular in American gardens since the eighteenth century.

Planting and Care: Lettuce needs warm days ranging from 66°F to 73°F and cool nights of about 45–52°F to grow well. Temperatures above 75°F soften the heads of head lettuce, and those above 85°F cause all but the most heat-tolerant lettuce to become bitter and to bolt.

Suggested Lettuce Varieties

Variety	Days to Maturity	Comments
Black Seeded Simpson	46	Heirloom; looseleaf; light-green crinkled leaves
Red Salad Bowl	51	Heirloom; looseleaf; burgundy colored
Ithaca	72	Heirloom; crisphead; disease tolerant
Summertime	70	Crisphead; good tolerance to hot weather
Buttercrunch	64	1963 AAS Selection; butterhead; slow bolting
Cimmaron	60	Cos; plum-red leaves with green veins
Green Towers	74	Cos; very dark green color

Well-hardened young lettuce can withstand 22°F with little damage, but all growth will be very slow at temperatures below 45°F. Lettuce's ability to tolerate cold temperatures decreases with age. So does ours.

Lettuce is a biennial crop we use as an annual, with the plant making most of its growth in the 20 days or so preceding maturity. Heads of lettuce, like cabbage, develop from the inside out, so the outermost leaves remain outermost throughout the plant's life.

A common problem is lettuce bolting before you can pick it all. When exposed to typical summer conditions following cool springs, it sometimes acts as though it is in its second season and produces a seed stalk. It's a plant for spring or fall harvest, not a summer harvest.

Most gardeners direct seed lettuce in early spring. Because lettuce seeds require light for germination, do not bury seeds. Remember that spacing affects the size of the lettuce head, so don't crowd it. As you thin, transplant the seedlings to other areas of the garden.

Lettuce transplants easily, and plants propagated this way mature a few weeks ahead of seeded plants. This is particularly advantageous with head lettuce since most heading varieties require a longer season.

Lettuce uses only a small amount of nutrients from the soil, but it is a poor forager because of its small root system, so nutrients must be made easily available near the plants. Apply your preplant application and side-dress lightly when the plants are thinned. Since you are after succulent leaves, be sure to give your lettuce plenty of nitrogen.

Lettuce requires plenty of water, but excessive amounts during hot days late in the season will cause head lettuce to become puffy.

Lettuce suffers from some environmental disorders. Tipburn causes brown spots along the leaf margins, is common in hot weather, and is associated with a calcium deficiency. Slower plant growth reduces the problem. Crisphead is more tolerant than other types.

Bolting results from exposure to long days, high temperatures, or extreme environmental stresses such as drought.

Harvesting: Looseleaf lettuce is harvested about 40–50 days after seeding, butterhead and cos 55–70 days after seeding, and crisphead about 70–120 days after seeding. Baby lettuce may be harvested anytime. Use scissors or a lettuce knife to harvest entire plants, leaving at least 1" of stem. The plants will regrow for 2 or 3 more harvests.

Sometimes brown spots develop on the lower midrib of lettuce leaves in the refrigerator. Called “russet spotting,” it’s caused by the plant’s reaction to ethylene.

What Happened Here?

My lettuce is bitter. This is probably due to high temperatures.

My lettuce flowered before we could harvest. This is due to high temperatures or drought; plant earlier and water well next year.

My head lettuce did not head. Thin your plants amply and give them enough room to form heads.

My head lettuce rotted. The weather could be too warm and damp from overirrigation. Time your lettuce planting to mature in cool weather.

Muskmelon

Cucumis melo (Cantaloupensis group)
Family: Gourd / Cucurbitaceae

Direct Seed or Transplant: Either, but usually direct seeded
Optimum Range of Soil Temperature for Germination: 80–90°F
Minimum Soil Temperature for Germination: 60°F
Optimum Range of Soil Temperature for Planting: 65–75°F
Minimum Soil Temperature for Planting: 60°F
Seed Planting Depth: ½"
Days to Maturity: 85–95
Seed Spacing within Row: Several per hill
Depth of Root System: Moderate
Thinned Spacing within Row: 18"
Consumption of Nitrogen: Moderate
Distance between Rows: 60–84"
Average Yield per 10' Row: 10 melons
Ease of Transplant: Requires special care

Grow Your Own Transplants

Optimum Range of Soil Temperature for Germination: 80–90°F
Approximate Length of Germination Period: 4–8 days
Approximate Time to Grow to Transplant Size: 4 weeks

Muskmelons belong to the same species as honeydew, casaba, true cantaloupe, and Persian melon, and all intercross readily within the species, resulting in many gradations among the fruit. The watermelon, on the other hand, belongs to a different genus and will not cross with any of these melons, nor will cucumber, which belongs to a different species.

Muskmelons require a long, hot growing season with optimum temperatures of 65–75°F.

Muskmelons are *andromonoecious*: They bear both perfect and male flowers, with male flowers appearing first. Unlike watermelon, which only produces 1 or 2 fruits per vine, muskmelon vines bear several fruit.

Planting and Care: To direct seed, plant several seeds in a hill and space those hills about 18" apart in the row, with about 6' between rows. A handful of composted manure in the bottom of each hole gets plants off to a good start.

If space is a premium, train the melon vines onto trellises, supporting each fruit with a sling or something similar, or plant them at the edge of the garden and let them sprawl onto the lawn.

Fun Fact

Muskmelons probably originated in western Africa or the Middle East. Columbus brought them to the New World in 1494, and the plants were reintroduced into North America by colonists in the 1600s. Very few true cantaloupes are grown in the United States; rather, you probably had a muskmelon with your breakfast, not a cantaloupe. Blame the marketeers who changed the name as a ploy to increase consumption of the fruit, since "cantaloupe" sounds so much more exotic than "muskmelon."

Suggested Muskmelon Varieties

Variety	Days to maturity	Comments
Ambrosia	86	Orange flesh; 4 lb. fruit
Hales Best	80	Heirloom; orange flesh
Sweet Granite	70	Orange flesh; bred for mountain climates
Rocky Ford	84	Heirloom; green flesh; 2 lb. fruit
Minnesota Midget	70	Orange flesh; suitable for containers; 4" fruit

While muskmelons are not particularly heavy feeders, they should have nutrients sufficient to sustain uninterrupted growth through the season. Good vine growth supplies ample sugar to the fruit. Apply preplant fertilizer and side-dress the plants just before the vines begin to run.

Keep melon foliage dry by using drip irrigation or a soaker hose, for all melons are highly susceptible to both powdery and downy mildews. These diseases destroy the leaves and give you bitter or tasteless melons.

In addition to mildew, all melons are notorious for becoming infected with wilts. Breeders have released varieties that have built-in resistance to many of the diseases that made growing good melons difficult in the "old days." Select one of these resistant strains or varieties.

What Happened Here?

My melon leaves dried up and the fruit are tasteless. This was probably caused by powdery mildew; moisture and humidity are the culprits. Look for white powder on the leaves and use a fungicide. Also, keep irrigation water off the leaves. (If the leaves are dead, they cannot produce sugars for the fruit.)

I have bitter melons. Bitterness can be caused by cool weather during ripening. If cold weather is forecast during ripening, you could try holding in ground heat with covers.

Keep the weeds under control while your plants are young; once the vines begin to run, they smother the weeds.

Harvesting: Muskmelon fruit matures about 6–8 weeks after pollination. When fully mature and at its highest sugar content (10–12 percent), muskmelon fruit separates from the stem. This is called the "full slip" stage of development. Wait for this, and then pick

your melons.

Mustard Greens

Brassica juncea
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 77–95°F
Minimum Soil Temperature for Germination: About 50°F
Seed Planting Depth: ¼–½"
Days to Maturity: 35–55
Seed Spacing within Row: 1"
Depth of Root System: Moderate
Thinned Spacing within Row: 5–10"
Consumption of Nitrogen: Moderate
Distance between Rows: 12–36"
Average Yield per 10' Row: 10 lb.

Mustard is a hardy annual grown for its foliage. Like some other leafy greens, it will bolt in summer heat.

Planting and Care: Sow the seeds directly in the garden in the very early spring or sow them in late summer for fall use. Like other brassicas, it prefers fertile, well-drained soil high in organic matter.

Mustard varieties run the gamut from having very curled leaves to nearly smooth leaves.

Harvesting: Begin harvesting about 40–50 days after planting by cutting the entire plant at the soil line or snapping off the older outer leaves.

Fun Fact

Mustard greens, or leaf mustard, are grown for the leaves. Commercially prepared mustard, the condiment, is made from the seeds of the distantly related black mustard. Once quite popular, mustard greens lost their popularity to spinach and kale but, with the new interest in exotic greens, are enjoying a comeback. Mustard greens remain popular in India and central Africa as well as in the southern United States.

What Happened Here?

My mustard goes to seed very early. If this is happening in your spring planting, you may be running into hot weather. Try fall plantings.

My mustard is very strongly flavored. Weather is too hot or the soil is too dry.

Suggested Mustard Varieties

Variety	Days to maturity	Comments
Southern Giant Curled	48	1935 AAS Selection; heirloom; bolt resistant; popular curled leaves
Savannah	25	Mild flavor; rapid growing
Red Giant	40	Purple-red leaves; white midrib
Tendergreen	35	Heirloom; smooth, mild green leaves

Onion, Common

Allium cepa (Cepa group)
Family: Amaryllis/ Amaryllidaceae (formerly Alliaceae)

Direct Seed or Transplant: Transplant sets or plants
Optimum Range of Soil Temperature for Germination of Seed: 50–95°F
Minimum Soil Temperature for Germination of Seed: 35°F
Optimum Range of Soil Temperature for Planting Sets or Plants: 55–75°F
Minimum Soil Temperature for Planting Sets or Plants: 55–75°F
Set Planting Depth: 2–3"
Days to Maturity: 90–150 (see text)
Set Spacing within Row: 1–2"
Depth of Root System: Shallow
Thinned Spacing within Row: 3–4"
Consumption of Nitrogen: Moderate
Distance between Rows: 15–24"
Average Yield per 10' Row: 10 lb.
Ease of Transplant: Moderate to Easy

Grow Your Own Transplants

Optimum Range of Soil Temperature for Indoor Seed Germination: 50–95°F
Approximate Length of Germination Period: 10 days
Approximate Time to Grow to Transplant Size: 9–11 weeks

The common garden onion is a biennial grown as an annual. Its bulb is an accumulation of leaf bases; the bulb forms when plants are exposed to the proper day length.

Onions grow best at temperatures between 55°F and 75°F and do poorly when the temperature rises to 85°F or more, or drops below 45°F. Ideally, the weather should be cool during the early phases of onion development and warm during bulbing.

Onion bulbing is a response to day length, and onions are divided into 3 groups based on this. Short-day types grow best in southern gardens below 28°N latitude as fall and winter crops. Long-day types do best when exposed to 14–16 hours of sunlight. These are grown in northern gardens above 35°N latitude and are planted to mature in late summer. Intermediate types do best when given 13- to 14-hour days in latitudes between 28°N and 35°N. Leaf growth stops when bulbing begins, and the process depends upon existing leaves for bulb nourishment. It's important to plant onions early to get as much top growth as possible before the onset of bulbing.

Suggested Onion Varieties

Variety	Days to maturity	Comments
Candy	85	Intermediate; mild, sweet flavor; yellow
Red Candy	95	Intermediate; mild, sweet; red
Walla Walla Sweet	85	Long-day; white skin; mild flavor; poor keeper
Stuttgarter	102	Long-day; heirloom; long storage life

Fun Fact

The pharaoh supplied laborers building the Great Pyramid with onions,

garlic, and radishes. The Roman author Juvenal claimed the Egyptians worshipped sweet, mild onions. The Israelites complained to Moses that they could find no onions to eat in the wilderness. In 430 BC Greece, Hippocrates reported that onions were popular and several varieties were grown. Onions were used in Europe during the Middle Ages but were not as popular as leeks or garlic.

Columbus brought onions to Isabela Island in 1494, and from there they spread through the Americas, becoming especially popular with Native Americans. Massachusetts's colonists grew them in 1629, and Virginia harvested its first crop in 1648. Polish king Stanislas I popularized French onion soup during the reign of Louis XV.

Planting and Care: Onions grow best in rich soil high in organic matter and nutrients, so work in compost and broadcast some preplant fertilizer. The plant's small, shallow root system is a poor competitor for water and nutrients.

Planting methods depend upon the onion use. If you want them for dry bulbs, you can plant seeds, sets, or transplants in the very early spring after danger of hard freezes has passed. Onion sets produce a crop 3–4 weeks earlier and yield more than direct-seeded onions. Plant sets right side up about 3" apart in the row and cover them lightly with soil. The best sets are dormant and dime-sized. Smaller sets yield poorly and plants from larger sets will likely bolt. If you do plant larger sets, pay attention to where they are planted, and use them for green onions.

If you choose to seed, plant thinly in the row and don't thin. Keep in mind that onion seedlings are more prone to onion smut infection than onion sets, and that most Rocky Mountain gardeners opt for sets or grow or purchase their own transplants.

Pencil-thick onion transplants about 6" tall and 9–11 weeks old are planted 3–4" apart.

Side-dress the young plants about a month after planting. Adding nutrients, especially nitrogen, after this time delays maturity.

Onion plants must be well watered throughout the season, but excess water, like excess fertilizer, delays maturity and results in soft bulbs that store poorly. Stop watering when the onion tops begin to fall over to encourage the plants to "harden up."

A premature seedstalk is the result of improper storage temperatures. Large sets stored at 40–50°F are most likely to produce plants that bolt.

There are different types of dry bulb onions: round, flat, and globe-shaped bulbs in red, white, and yellow colors. They can be pungent (American type) or mild (foreign type) and short-day, intermediate-day, or long-day sensitive. Pungent onions are small, dense, and strong-flavored. Though all 3 colors exist within this type; the most popular are yellow bulbs. The pungent type stores far better than the mild type. Mild onions are best typified by the 'Bermuda', a short-day type grown widely in the US South.

Harvesting: Any densely planted onions can be pulled for green onions starting when they are about pencil thick.

Pull onions for dry bulbs when the tops on most of the plants have fallen over but before the foliage has dried completely. If you delay harvest, the bulbs may sprout new roots and will not store well. Do not break the tops over but let them fall naturally, as breaking them over reduces yield. after harvest you must cure the plants.

Curing onions: Pull the plants and put them into long, narrow piles in the garden with the tops of 1 row covering the bulbs of another to reduce bulb sunburn, or remove them from the garden and cure them out of direct sunlight. Let them cure until the tops are completely dry, between 5 and 14 days, depending upon the weather. If the weather is wet, cure them in the shed on something like a piece of 1" mesh poultry fencing supported by 2 x 4s laid between sawhorses so that air can circulate around the bulbs.

What Happened Here?

My bulbs are very small. They didn't receive enough water or fertilizer or there were too many weeds during bulb formation. The plants may also have been crowded.

When the tops have dried completely, cut them off, leaving about 1" above the bulb, and place the sound, firm bulbs into a mesh bag with large holes. Be sure they have good ventilation all around. Store them in a cold, dry place that does not freeze. Damaged bulbs and those with thick necks will not store well.

Parsnip

Pastinaca sativa
Family: Parsley / Apiaceae (formerly Umbelliferae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 50–70˚F
Minimum Soil Temperature for Germination: 35˚F
Seed Planting Depth: ½"
Days to Maturity: 105–120
Seed Spacing within Row: 3"
Depth of Root System: Deep
Thinned Spacing within Row: 2–4"
Consumption of Nitrogen: High
Distance between Rows: 18–36"
Average Yield per 10' Row: 7½ lb.

Parsnips require a 100- to 130-day season. They are not as heat tolerant as carrots and grow best at cool temperatures between 60˚F and 65˚F.

Planting and Care: Parsnips require a deep soil free from hardpans and stones. The roots become crooked in shallow soils. Heavy clay soils, especially where the surface crusts before germination, produce a poor stand with roughened roots.

Fun Fact

This native root of Europe and Asia was relished by the Greeks and Romans. Pliny extolled its medicinal value. The emperor Tiberius liked it so much he had it imported fresh from Germany. Parsnips grown in ancient times did not have the large, white, fleshy root we know today. This characteristic developed during the Middle Ages, when the English ate the roots during Lent. Parsnips were brought to North America by the early colonists and were cultivated in Virginia in 1609 and in Massachusetts by 1629. General Sullivan, in his 1779 punitive expedition against the Six Nations in New York, found the Native Americans growing parsnips.

Prepare a fine seedbed and plant in the early spring. If the plants are crowded, the roots will be small but tender; if too far apart, they'll grow too large and rapidly become woody and fibrous.

Parsnip seeds take up to 3 weeks to germinate, and you'll usually have to weed before the parsnips appear. Use radish as a nurse crop and continue to cultivate to control weeds. You can also cover the seeds with peat moss, vermiculite, or sand to keep the soil from crusting over them until seedlings emerge.

What Happened Here?

My parsnip roots are full of tunnels and worms. They have root maggots or wireworms. Try planting a trap crop of radishes near the parsnips next year or, better still, avoid planting root vegetables in that part of the garden for at least 3 years.

I had very poor results from new parsnip seeds I purchased. Parsnips are notorious for having poor germination and seedlings; seeds lose their viability very rapidly and the seedlings are weak. Be sure to use a nurse crop of radishes to help the seedlings break through any soil crusting.

Fertilize parsnips as you would carrots. Begin cultivation as soon as weeds emerge and continue until the plants' foliage shades the area between the rows.

Harvesting: Starch in the root is converted to sugar when temperatures fall below about 37°F. The roots are very long, so you can't pull them like carrots; dig them after several hard frosts and store them in your root cellar. Alternatively, leave them in the garden, mulched with leaves, and dig them through the winter into early spring before the tops resume growth; growing tops indicate shriveled, tasteless roots.

Suggested Parsnip Varieties

Variety	Days to Maturity	Comments
Hollow Crown	105	Heirloom; medium-long roots
Harris Model	120	Heirloom; fine grained; sweet flesh
Javelin	110	Vigorous; canker resistant

Pea, Garden and Edible-pod

Pisum sativum–garden pea
Pisum sativum vars.–edible-pod pea (snap and snow)
Family: Pea or bean / Fabaceae (formerly Leguminosae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 40–75°F
Minimum Soil Temperature for Germination: 40°F
Seed Planting Depth: 1"
Days to Maturity: 49–75
Seed Spacing within Row: 1–2"
Depth of Root System: Moderate
Thinned Spacing within Row: 1–2"
Consumption of Nitrogen: Low
Distance between Rows: 24–36"
Average Yield per 10' Row: 2 lb.

Garden peas are legumes, but they are not the same as cowpeas, which are actually beans. Beans, snap or cow, are warm-season plants, while peas will not tolerate warm summers unless they have been specially bred for heat tolerance. Pea plants, unlike bean plants, can withstand some frost, but the flowers and pods cannot.

There are several types of peas that differ in growth habit and height. Like tomatoes, pea vines can be determinate or indeterminate. The determinate types, also known as the dwarf or bush peas, are very popular with gardeners. They generally reach heights of 18–30" and seldom require staking, although staking will make harvest easier. The indeterminate-type peas (climbing, telephone, or pole pea) reach heights of up to 6' and need support. These are much less commonly found.

Fun Fact

Peas are thought to have originated in the eastern Mediterranean. Archaeologists dated dried peas buried in Switzerland to at least 7000 BC. The Chinese were using peas by 2000 BC, and they spread to Greece, Rome, and Egypt shortly thereafter. Interestingly, only dried peas were used; green peas were considered unfit to eat. Colonists brought the garden pea, by then called the English pea, to America in the early 1600s.

Within each type breeders have developed peas with edible pods. Scientists created them by crossing a podded pea with a mutant strain. Snow peas are grown for their flat pods and immature peas. Sugar snaps have a tender pod that becomes full and succulent and may be snapped and eaten along with the immature peas inside, just like snap beans. When the peas in sugar snaps mature, they can be shelled like garden peas.

Planting and Care: While pea plants form taproots that may extend to depths of 3–4', many of their feeder roots are near the soil's surface.

Edible-podded peas are more susceptible to mildews and need more careful watering than garden peas. Peas in general need well-drained soil high in organic matter. They are one of the first crops to go into the garden, but don't rush it. Pea seeds won't germinate in soil temperatures less than about 40°F, and the plants won't grow below 45°F.

Some gardeners plant peas in double rows about 3–4" apart, with 2–3' between the double rows. This method provides more space for harvesting. Double rows of peas may also theoretically support each other, but I still use trellising in my garden.

What Happened Here?

My plants are strong and lush but have no peas. They probably just need more time. You can pinch the tips if you want to. Perhaps you applied too much nitrogen fertilizer.

My pea pods are shriveled and swollen. They're overmature. Next year pick at the correct time.

The leaf tips are dying, and the plants look limp. You may not have been watering enough, or the weather was just too hot for your variety. It could also be a disease. When in doubt, take a sample to your county extension office for diagnosis.

There's a white powdery layer on the leaves. Powdery mildew is the suspect. Apply water to the soil, not the leaves. Edible-podded varieties are more susceptible.

Legumes like peas and beans harbor bacteria (*Rhizobium* spp.) in root nodules that "fix" atmospheric nitrogen into a form useful to the plant. So, before planting, some gardeners treat their seeds with the proper *Rhizobium* inoculant. (Inoculants are specific to the plants they "infect," so be sure to get the right one for your peas!) The theory is that if the ground has not been planted to peas within the last 5 years, the bacteria will not be present, so it must be added. Some scientists don't agree that it's that important and maintain the bacteria are present in soils anyway. The inoculant is inexpensive, and if you'd like to try it, do.

Set stakes for supports at planting. Lodging (falling over) increases the amount of bird and slug damage and reduces yields. Stakes or poles set firmly into the ground several feet apart along the row serve as a good trellis framework. String heavy twine between the stakes about every 1–2' apart vertically, then zigzag twine between them. The peas grow up the twine. You can also use chicken wire, snow fence, or other material supported by the posts. Keep in mind, however, that if you are going to reuse your trellis

material next year, you will need to pick the dead plants off the support this year. An old method is to stick branches into the ground along the row. When the crop is harvested, simply chip and compost, burn, or throw away the branches with the vines.

Supplemental nitrogen is usually not necessary for good pea plant growth due to their ability to fix atmospheric nitrogen. In fact, excess nitrogen may delay pod set in determinate varieties.

Harvesting: Harvest peas by grasping the pods in your hand and snapping them from the stem. Cool them rapidly to prevent the sugar from converting to starch; I've always harvested early in the morning. If you harvest later in the day, use a large plastic storage bin with cold water to cool them quickly. Cool weather stretches the harvest over several days, but peas will only hold 1–2 days when ready for picking. Sugar in peas turns to starch more rapidly in warm weather, so you will need to harvest more quickly. Garden pea pods that feel hard and look crinkly are overmature. Read the seed descriptions carefully when ordering seeds, as some varieties produce pods containing 5 or 6 seeds, while others may have up to 14 seeds in each pod. Seeds of snow peas should be no larger than BB shot, and the pods should be stringless and succulent. If they get ahead of you, you may still use them in your stir-fries by slicing them diagonally.

Suggested Pea Varieties

Variety	Days to maturity	Comments
Knight	62	Garden pea
Green Arrow (Green Shaft)	62	Garden pea
Early Frosty	64	Garden pea for cool springs
Wando	67	Heirloom garden pea; tolerates some heat
Sugar Ann	58	AAS Selection; snap pea; disease resistant
Sugar Snap	70	AAS Selection; classic snap pea
Oregon Sugar Pod #2	65	Snow pea; early, flat pod; disease resistant

Peppers

Capsicum annuum
Family: Potato or nightshade / Solanaceae

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 70–75˚F (sweet); 70–85˚F (hot)
Minimum Soil Temperature for Planting: 65˚F
Transplant Spacing within Row: 12–24"
Days to Maturity: 65–80
Distance between Rows: 18–36"
Depth of Root System: Moderate
Ease of Transplant: Moderate
Consumption of Nitrogen: Moderate
Average Yield per 10' Row: 5–7 lb.

Grow Your Own Transplants
Optimum Range of Soil Temperature for Germination: 65–95˚F
Approximate Length of Germination Period: 5–7 days
Approximate Time to Grow to Transplant Size: 8 weeks

Peppers are perennial tropical plants grown as annuals. They are more chill sensitive than tomatoes and don't tolerate prolonged periods below 50˚F, nor will they set fruit below 60˚F. Sweet peppers make their best vegetative growth between 65˚F and 85˚F. Temperatures above 85˚F cause misshapen fruit, and those above 90˚F cause flowers to abort.

Hot peppers grow best above 75˚F with consistently warm night temperatures above 70˚F. Temperatures above 90˚F actually increase fruit set. Like sweet peppers, hot peppers will not set fruit when temperatures fall below 60˚F.

All peppers quickly abort their flowers in waterlogged soils.

Common peppers are determinate, erect, bushy plants 1–3' tall. They have moderately sized root systems and cannot forage widely for nutrients. Their stems and leaves are brittle and break when soil moisture is high and/or the plant has a heavy fruit load. Stake the plants as you would tomato plants when there's a chance of windy conditions.

The plant is day-neutral, but flower buds form faster under long days and warm temperatures. Fruit forms following pollination.

Planting and Care: Because of their need for lots of heat, peppers are transplanted to the garden well after the danger of frost has passed. Large transplants produce a large, early yield but may not give as large a total yield as slightly smaller transplants. Overhardening stunts plants and reduces total yields.

Use a liquid transplant fertilizer and side-dress with a dry fertilizer when the plants have set several fruits. Using manure or compost in the planting hole never hurts, though peppers do not respond to them as well as do some other vegetables.

Fun Fact

*There are sweet peppers and pungent peppers, but all grown in the United States, except one—Tabasco (*C. frutescens*)—belong to the same species*

*(and Tabasco is sometimes thought to belong there, too). None are closely related to the spice black pepper (*Piper nigrum*). They were gathered from the wild at least 7,000 years ago and cultivated at least 2,000 years ago in their native Central America, where most wild types are very hot. Columbus brought chili peppers to Europe in 1493 and their use spread rapidly. The fruits were dried, ground, and used as a substitute for expensive black pepper. Peppers became so valued that jalapeños were bartered and used to pay taxes during the Spanish conquest of Mexico. Chili peppers were being cultivated extensively in India by the late 1500s.*

Excess water causes the flowers and small fruit to abort, while too little water increases the incidence of blossom-end rot. Soaker hoses or watering the soil (not the leaves) with a watering can are best.

Mulching is the best way to control weeds in peppers. Black plastic increases the yield of high-quality fruit. If you choose to use straw, leaves, or another organic mulch, let the soil warm up before you apply them.

The many varieties of peppers can be confusing.

Bell Types: Plants produce large, sweet, blocky fruit up to about 4" wide and 4" (or more) long. Immature green fruits turn red or another color at maturity, but most are eaten green.

Pimiento: These plants produce sweet, round to slightly pointed fruit about 2" wide and 3–4" long. The fruit is used to stuff green olives and is also eaten in salads.

Celestial: Plants bear small fruit up to 2" in diameter. These stand upright on the plant. The fruit may be red, yellow, orange, or purple, and fruit color can be mixed on a single plant. The plants are used as ornamentals, and hot fruit are often ground for addition to chili powders.

Cayenne: Fruits from these plants are slender, curved, pointed, and 2–12" long. They are green when immature and red when mature. Fruit of the sweet types are ground into paprika, while those of the hot types are used in chili powder.

Cherry: These plants produce cherry-shaped fruits that are orange or red at maturity and can be sweet or hot. They are pickled or ground for chili powder.

Tomato: Fruits resemble small, green tomatoes and are pickled when they are immature.

Tabasco: These plants produce slim, very hot fruit up to 3" long. They are used as ornamentals, pickled, or ground for use in chili

powder.

The fruit of most traditional pepper varieties is green when immature and red when mature, particularly that of the open-pollinated types. Gardeners now have their choice of hybrid bell-type peppers that are yellow, orange, chocolate-brown, or purple.

The pungency or “hotness” of pepper fruit is expressed in Scoville heat units. The nonpungent, sweet bell types rate 0; the Anaheim, 150–2,500; and the jalapeño and cayenne, 10,000–18,000. Tabasco peppers rate in the vicinity of 40,000 units. The variety ‘Berbere’ from Ethiopia rates up to 100,000 units. The pungency is due to the presence of an alkaloid—capsaicin. This compound is extracted and used to produce “warmth” in some topical balms. It is the irritant in Mace and, as “pepper spray,” an effective bear repellent. Scientists believe hot peppers are so popular because they increase our general metabolism, salivation, and the release of endorphins in the body, creating a sense of well-being.

Peppers develop only a few physiological disorders that should not be problems for most gardeners. Blossom-end rot can occur under very dry soil conditions and is related to poor calcium distribution in the plant. See the discussion of this disorder under the tomato entry.

Sunscald shows as off-white colored blotches and papery dead skin on fruit exposed to direct sun. This can be a problem when plants are partially defoliated.

Harvesting: Pepper fruit are harvested from 60 to well over 100 days after planting, provided you have the season for it. If you want red bell peppers, wait for the fruit to mature before picking. Otherwise, pick the fruit at any time it has reached acceptable size, usually 3–4" in length. Harvest all peppers by snapping the stem from the plant. Be sure to support the rest of the plant when you snap off the fruit. Pick the largest fruit every 7–10 days. Green fruit will redden off the plant if stored above 50°F, but bacterial soft rot can become a problem. Wear gloves when you harvest or cook with hot peppers.

What Happened Here?

All the flowers dropped from my pepper plants. The weather has been too cold or very hot or you waterlogged

your soil by overwatering.

Late in the season, my bell pepper fruit acquire a purple cast. If it's got a purple cast it won't turn red. This off-color is common on green jalapeño and bell peppers near the end of the season and is caused by cool weather and shorter days, but the fruit remains edible.

How do I know when to pick my peppers? When a pepper has developed the color and size you want, pick it.

Suggested Pepper Varieties

Variety	Days to maturity	Comments
California Wonder	75	Heirloom; sweet bell type; great for stuffing
Big Bertha	70	Sweet bell type; very large fruit
Lunchbox Snack Red	55 green / 75 red	Sweet and 2½" long; snack-type
Sweet Banana	66	1941 AAS Selection; heirloom; pimento type; ripens red; sweet
Jimmy Nardello's	80	Heirloom; 10" long sweet skinny peppers for frying
Thai Dragon	75	Dries easily; very hot
Hungarian Wax	70	Cayenne type; medium hot
Jalapeño	65 green / 80 red	Cayenne type; very hot
Ancho (when dried); Poblano (when fresh)	68 green / 88 red	Heirloom; mildly hot
Habanero	75 green / 100 ripe	Very hot
Aurora	70	Celestial type; lavender, purple, orange, red; medium hot

Potato, Irish

Solanum tuberosum
Family: Potato or nightshade / Solanaceae

Direct Seed or Transplant: Plant tuber pieces
Optimum Range of Soil Temperature for Growth: 60–65˚F
Minimum Soil Temperature for Planting: 45˚F
Seed Planting Depth: 4"
Days to Maturity: 90–120
Seed Spacing within Row: 10–12"
Depth of Root System: Shallow
Thinned Spacing within Row: 10–12"
Consumption of Nitrogen: High
Distance between Rows: 24–36"
Average Yield per 10' Row: About 20 lb.

The potato is a close relative of the tomato, pepper, and nightshade, but is not related to the sweet potato. We grow potatoes for their fleshy underground tubers and treat them as an annual, although they are actually perennial in their native habitat. Gardeners often find volunteer potato plants in the garden the following year, as new plants grow from plant debris left after harvest. Volunteer potato plants should be pulled and destroyed to avoid perpetuating potato diseases that overwinter in unharvested tubers, particularly if you live in or near an area where potatoes are grown commercially.

Planting and Care: Potatoes are planted using pieces of seed tubers with at least 1 bud, also called an "eye." Seed potatoes come in different sizes; each should be about the size of a silver dollar and weigh at least 2 ounces. Remember that the plant will live for its first month exclusively on food it gets from the seed piece. If you buy small-sized tubers, you can plant the entire tuber. You might get a more vigorous plant by planting larger pieces, but there isn't much difference. Just be sure your tubers haven't sprouted before planting and that they appear to be healthy. Be sure to purchase your seed potatoes from a reputable company and that they are certified disease-free. Do not plant potatoes that have been harvested for eating.

Holding freshly cut seed pieces at 60˚F for about a week before planting allows the wound to cure, making them less apt to rot when planted.

Plant the pieces when soil temperature has warmed to about 45˚F after the danger of a hard frost has passed. Set them 4" deep in a trench and fill it slowly as the potato plant grows, lightly covering the apex of the plant until the trench is filled in. Potato tubers grow along the underground stems that grow from eyes on seed pieces.

Some folks modify the trench planting system by covering the plant apex with straw or pine needles instead of soil. This allows them to easily harvest clean spuds by simply pulling away the mulch.

Don't plant when the soil is wet, as potatoes are very sensitive to poor drainage and poor soil aeration. Their roots will not grow into compacted soil.

Potato plants have a high fertility requirement and small root

systems, so turn under rotted manure and your cover crop and apply all the fertilizer prior to planting. Never apply fresh manure to potatoes since it may increase the incidence of a disease called "scab" (see page 268). If you have very sandy soil, side-dress about a month after planting. Otherwise, side-dressing does little good with potatoes.

Fun Fact

These delicious tubers probably originated in the Andean area of Peru and Bolivia. The Incas cultivated them at least 2,000 years before Spanish explorers introduced them to Europe in the early 1500s, and Sir Walter Raleigh introduced potatoes to the Irish in 1585. They were planted in Virginia in 1584, but there is no mention of their use elsewhere until they were brought to Londonderry, New Hampshire, by Presbyterian Irish settlers in 1719, hence their name "Irish" potato. Even then, they were not generally cultivated until the nineteenth century, though they were grown as a field crop in Salem, Massachusetts, in 1762. The impoverished Irish became so dependent upon one strain of the potato that an estimated 3/4 million of them starved to death when their crops were destroyed by infestations of late blight in 1845 and 1846. That blight also sparked a huge wave of Irish emigration to the United States.

At first, 1 stem grows from each bud, but more can grow as the season progresses. The aboveground stems grow upright during the long days of summer, forming a bushy plant. Flower blossoms range in color and may be a solid color or combination. Potato tubers form just about the time these flowers bloom. The flowers may drop off before they open, especially in tough weather. Not all potatoes flower every year, but you should get a crop regardless. As the season progresses, the plants start to sprawl.

The potato is a cool-season crop that is moderately tolerant of frost. Growing temperature is critical and is one of the most important factors in good yields. The plant stops growing when temperatures fall below 45°F or rise above 75°F, and produces the best yields at 60–65°F. Use an organic mulch to cool the soil and help produce a better crop.

Consistent moisture is important for good growth. Yields will be substantially reduced if there is a dry spell for a couple of weeks, and excessive watering after the tubers have formed can cause them to rot. Inconsistent or inadequate moisture can cause many physiological disorders in potatoes.

Keep on top of your weeding in the potato patch, but don't cultivate more than 2" deep. In midseason, if you haven't already done so, mound soil over the bases of your potato plants (called "hilling"). Hilling covers the spuds and protects them from the sun's bright rays, which will cause any exposed tuber parts to turn green, bitter, and poisonous. This process, called tuber "greening," occurs when the tuber is exposed to light. The potato tuber is a modified stem, not a root, and plant stems can manufacture the green pigment chlorophyll when exposed to light. Now, chlorophyll won't hurt you, but that is not the problem. Green skin and flesh indicates that another compound—solanine—has built up along with the chlorophyll. Solanine is bitter tasting and can give you a pretty bad stomachache, or worse if eaten in large quantities. Since most of the chlorophyll and solanine is located near the surface of the tuber, peeling will remove much of them. But if you'll just take the time to hill the crop, you can avoid the problem in the field altogether.

The potato fruit, a small green berry that grows aboveground, resembles a small tomato and can contain up to about 300 seeds. But don't bother to save them unless you plan to breed your own potato variety. Potato seeds are genetically unstable and will produce many off-type plants. So if you plant seeds saved from your 'Yukon Gold', you might have many plants, but none will be 'Yukon Gold'. Potato fruits are poisonous, too. Remove and destroy them if you have small children around who might mistake them for tomatoes.

What Happened Here?

The leaves look brown and have spotted areas. This could be blight, especially if it started as a purplish spot. There are many diseases that affect potatoes, so when in doubt, take a sample to your local county extension office for positive identification, particularly if you live in or near an area of commercial potato production. Destroy the plants and follow your county agent's recommendation for control in the future.

My potatoes turned green in the sunlight. Are they poisonous? Be sure to hill your potatoes to protect them from sunlight. The green area of potatoes contains a toxic

alkaloid (solanine), so it's best to cut that green out before preparing your spuds or discard them altogether.

My stored potatoes become very sweet. Starches in potatoes will turn to sugar if you've stored them in temperatures below about 40°F. Move them to an area where the temperatures are above about 55°F and the sugars will turn back to starches.

Suggested Potato Varieties

Variety	Comments
Dark Red Norland	Heirloom; red skin, white flesh; standard early potato
Superior	Early white skinned, white flesh; scab resistant
All Blue	Blue skin and flesh; lightens when cooked
Magic Molly	Purple skin and flesh; fingerling
Yukon Gold	White skin, yellow flesh; midseason; good storage
Kennebec	Heirloom; white skin, white flesh; late season
Red Pontiac	Heirloom; red skin, white flesh; midseason to late

Potato tubers are susceptible to a pathogen that causes scab. The fungus doesn't grow well in acidic soil, so if your soil has a pH of about 4.8–5.4, scab will not be prevalent. If your soil pH is high as are most soils in our region, consider forgoing a spud crop, or find a scab-resistant variety to plant.

Internal black spot is the result of a bruised seed piece in combination with excessive water and nitrogen. The tissue just beneath the skin of the tuber turns black, and the potato loses a lot of eye appeal. Be careful not to bruise your seed potatoes at planting time!

Hollow heart is the formation of a cavity near the center of the tuber caused by uneven growth resulting from uneven moisture supply.

Flea beetles are tiny, shiny black beetles that overwinter in the soil and feed on your potatoes' leaves. They chew tiny holes that make the leaf look like it received a blast from a tiny shotgun. Their larvae feed on roots and tubers. Rotate your potato crop around your garden.

Many potato varieties are available in different skin and flesh colors. While the most popular to consumers in the United States

are white-fleshed, there are yellow, pink, red, and blue-fleshed tubers commonly available, and folks are enjoying trying them in their gardens.

Harvesting: Dig your potatoes about 2 weeks after the vines have been killed by the first frosts of the season. If you dig too early, when the vines are still living, your spuds' skins will be tender and will skin and bruise easily. Avoid too much sunlight exposure before storing your potatoes. To store them, hold them at 50–60°F for about a week to allow them to cure. Then lower the temperature to about 40°F, where they will keep for up to 6 months. While they will not sprout if stored below 40°F, their starch will turn into sugar and the potatoes will taste sweet. That is not a problem for most folks with normal digestion, unless you intend to fry your potatoes, as the sugar that has formed will caramelize and the resulting potatoes will be dark brown.

Radish

Raphanus sativus
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 45–90˚F
Minimum Soil Temperature for Germination: 40˚F
Seed Planting Depth: ½"
Days to Maturity: 22–30
Seed Spacing within Row: Thinly
Depth of Root System: Shallow
Thinned Spacing within Row: ½–1"
Consumption of Nitrogen: High
Distance between Rows: 8–18"
Average Yield per 10' Row: 10 bunches

Easy-to-raise radishes are grown as annuals for their fleshy, often pungent root. They may be grown for a spring or fall harvest in our region, but they will not tolerate summer's heat. Any check in growth will cause the roots to become punky, woody, and too pungent. Warm weather may also cause the plants to bolt.

Fun Fact

We know the pharaohs enjoyed radishes 4,000 years ago, but this vegetable actually originated in Asia and Europe. They were well loved by Greeks, who cast small golden replicas of the roots. New forms were developed in China after their introduction to that country in 500 BC. Radishes were introduced into England in 1548 and were cultivated in the United States by the early seventeenth century.

Generally, there are 2 types of radishes; the more familiar is

called a “spring” or “salad” radish, which matures in 3–6 weeks. The winter radish is less common and slower growing, requiring 45–70 days to mature.

One of the quickest seeds to germinate, radishes are good for novice gardeners and children to plant. But beware—a child who pulls a beautiful red radish, washes it, and takes a bite just might not want to repeat the experience (and might be more than a little mad at you!). Because radish seeds germinate quickly, you can mix them with more slow-to-germinate seeds, like carrots, beets, and parsnips for a nurse crop.

What Happened Here?

My radish plants produce mostly tops. Planting too late in the spring or too thickly will result in radishes with little “radish.” Next year, plant earlier and remember to thin your seedlings.

The radishes taste too “hot” for me. If growth slows, radishes will develop a very strong taste. Be sure to water thoroughly and consistently.

There are worms in my radishes. Cabbage root maggot will

infest radishes, too. Destroy the plants and rotate susceptible crops.

Suggested Radish Varieties

Variety	Days to maturity	Comments
Cherry Bell	24	1949 AAS Selection; heirloom; very attractive; high quality
Early Scarlet Globe	22	Heirloom; very crisp, white flesh
French Breakfast	25	Heirloom; olive shaped; bright scarlet color
Watermelon	60	Heirloom; daikon type; white outside, rose inside; fall crop
D'Avignon	21	Traditional long French variety; red with white tip
Black Spanish	55	Heirloom; black skin; long keeper; 4"-diameter roots

Planting and Care: Radishes do best in light soils. You will end up with oddly shaped roots if your soils are stony, or if you forget to thin, you may find no radish "root" at all.

Spread fertilizer before you plant radishes; there'll be no time to side-dress during their short growing season.

Spring radishes are most popular. The little globe-shaped, red roots are attractive in salads and garnishes. Radishes come in many shapes and colors, as well as pungencies, so be sure to read the description in your catalog. Late-summer radishes are not widely grown in the United States, but you can try some in your garden. They take slightly longer to mature than the spring varieties. Winter radishes generally take about twice as long to mature as do spring varieties, and are grown for a fall crop. They also come in different pungencies and colors.

Harvesting: Harvest spring radishes when roots reach 1–1½" in diameter. If you leave them in the ground too long, they'll develop a strong flavor and crack.

Store spring radishes in the refrigerator for a few weeks, but remove the tops prior to storage or you'll end up with a vegetable drawer full of mush. The leaves don't store well.

Rhubarb

Rheum rhabarbarum
Family: Buckwheat / Polygonaceae

Direct Seed or Transplant: Plant crowns with at least 1 “eye”
Optimum Range of Soil Temperature for Planting: 50–70˚F
Minimum Soil Temperature for Planting: 50˚F
Planting Depth for Crowns: Place eyes 2" below soil surface
Depth of Root System: Extensive
Consumption of Nitrogen: Very high
Spacing within Row: 24–48"
Average Yield per 10' Row: 20 leaf stalks
Distance between Rows: 36–48"

Rhubarb is highly tolerant of drought and severe cold and grows best in spring and fall where summer temperatures average 75˚F and winter temperatures, 40˚F. It begins growth when temperatures reach 45˚F. In the cool spring the leaf stalks develop their characteristic red color. Vegetative growth slows considerably in summer, the leaf stalks turn green, and the plant produces a long flower stalk. Vegetative growth resumes in fall and the stalks become red again, finally dying when temperatures drop to about 26˚F.

Planting and Care: Rhubarb is a very heavy feeder and does best in a well-drained high organic soil.

Fun Fact

Rhubarb is grown for its tart petioles (leaf stalks). It first was brought to Europe (Italy) from Siberia about 1608. It appeared in America in 1778 and was commonly grown by 1806. When the Nazi army overran the rich fruit-growing districts of Russia during World War II, Joseph Stalin authorized the importation of tons of rhubarb seeds from the United States. These were planted in secure northern regions of the country and supplied Soviet citizens with plenty of “fruit.”

Cut crown divisions into as many pieces as there are strong buds on the outer portion of the old crown and plant these in spring or in late fall. Set the divisions 2–4' apart and 2" deep, firming the soil around their sides but leaving the soil directly over their bud loose. Water well.

Once established, side-dress the plants in the spring with a complete fertilizer. Some gardeners cover the plants for winter with composted manure, but using manure or heavy organic winter mulch is not advised where foot rot is a problem because this pathogen thrives in soils that remain damp for long periods of time.

Suggested Rhubarb Varieties

Variety	**Comments**
Valentine	Bright red stalks; better adapted to slightly warmer sites; bolt resistant
Canada Red	Bright red stalks; better adapted to slightly warmer sites
MacDonald	Old Canadian variety; produces pink stalks
Victoria	Very old Canadian variety; large plant produces green stalks
Crimson Red	Sweet and tart; plump red stalks

What Happened Here?

My plants produced seedstalks. The weather got too hot and the days too long. Remove and discard the seedstalks. Some varieties flower very early in the season.

I planted rhubarb seed I saved from the previous year, but nothing grew. Seed viability is terrible; go with crown divisions.

Harvesting: Harvest for 1–2 weeks from vigorous plants in their second season, but by their third season, a harvest of up to 8–10 weeks may be possible if plants remain vigorous. Don't harvest for longer than that, and harvest in either spring or fall (preferably the former) but not in both.

Pull the leaf stalks from the plant and remove the leaf blades before storage. ***Caution:*** The leaf blades are poisonous; they contain toxic amounts of oxalic acid. *Do not eat them!* Discard them (or use as a weed barrier around the plant) and eat only the petioles.

The plants will become crowded after 8–10 years, and their leaf stalks will become spindly. Divide the plants, transplant the divisions to new areas, and give the old plants a good dressing of manure and fertilizer.

Rutabaga

Brassica napus (Napobrassica group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 45–95°F
Minimum Soil Temperature for Germination: 40°F
Seed Planting Depth: 1"
Days to Maturity: 90–95
Seed Spacing within Row: 1–2"
Depth of Root System: Moderate
Thinned Spacing within Row: 5–8"
Consumption of Nitrogen: Moderate
Distance between Rows: 18–36"
Average Yield per 10' Row: 15 lb.

People confuse the rutabaga and turnip, but savvy vegetable gardeners know the difference. They have similar cultural requirements, and both are grown for their enlarged fleshy root. Rutabagas found in the local grocery store typically have yellow flesh, while turnips are typically white-fleshed, but both boast varieties with flesh of other colors. The turnip is a smaller plant with smaller roots that may be round, elongated, and sometimes slightly flattened. They have no neck, and are usually white to tan in color, with purple near their top. Leaves of the turnip plant are typically hairy, rough, thin, and green. A rutabaga has a larger, round root with a thick neck and smooth blue-green leaves. The root is usually tan.

Fun Fact

Closely related to turnips, rutabagas are native to northern Asia, the Near East, and Afghanistan. They are more nutritious than turnips, and many turnip lovers are turning to rutabagas for a tasty treat.

It's thought that the rutabaga evolved in Europe from a cross between kale and turnip. It was introduced into England about 1790 and America around 1800. The rutabaga is also known as swede, swede turnip, and winter turnip.

Planting and Care: Rutabagas tolerate low temperatures and do poorly when temperatures get too warm. Like turnips, they are biennial, so exposure of young plants to 50–55°F will cause them to bolt. Time the planting so that the roots will mature during cool weather. Rutabagas require 85–95 days to mature and are better grown as a fall crop in the Rocky Mountain region.

Like turnips, rutabagas are sensitive to boron. Watch for brown heart or water core, which is characterized by breakdown of flesh at the center of the root. It typically shows up during periods of rapid growth. Have your soil tested professionally and follow the recommendations of the soil lab before applying too much of any boron-containing compound.

What Happened Here?

The root core is brown. This is typically caused by a boron deficiency. Have your soil professionally tested and follow the lab's instructions for amendments.

There are shot holes in the leaves. These are usually caused by flea beetles, small (1/16"), usually dark-colored beetles that travel on the wind. Row covers applied at planting are effective in protecting your garden.

My rutabagas have tunnels in their roots. Root maggots cause damage to many root crops. They overwinter in the soil, so rotate your crops next year and don't plant susceptible vegetables in that spot. The adult of the root maggot is a flying insect and may be excluded from an uninfested location with the use of row covers at planting. Row covers will not help if they are placed over an area where the root maggot has overwintered.

Suggested Rutabaga Varieties

Variety	Days to maturity	Comments
American Purple Top	90	Heirloom; excellent fresh or stored for winter use
Laurentian	95	Mild flavor; pale yellow flesh with purple tops
Helenor	90	Very high yielding; sweet orange flesh

Harvesting: Rutabagas taste best when the roots are 3–5" in diameter and when they mature in cool weather.

Salsify

Tragopogon porrifolius
Family: Sunflower / Asteraceae (formerly Compositae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 70°F
Minimum Soil Temperature for Germination: 35°F
Optimum Range of Soil Temperature for Best Growth: 55–75°F
Minimum Soil Temperature for Best Growth: 45°F
Seed Planting Depth: ¼"
Days to Maturity: 110–150
Seed Spacing within Row: 1"
Depth of Root System: Moderate
Thinned Spacing within Row: 3"
Consumption of Nitrogen: High
Distance between Rows: 24"
Average Yield per 10' Row: 6 lb.

Salsify is also called "goat's beard" from the appearance of its foliage, and "vegetable oyster" or "oyster plant" from the taste of the root. Sweet salsify roots have an interesting, subtle, pleasant flavor and are a prime ingredient of mock-oyster stew.

Salsify is a hardy biennial plant, grown for its 12"-long, 1"- to 2"-thick fleshy taproot. It requires a growing season of 110–150 days. If you can grow parsnips, you have a good shot at growing salsify.

Do not confuse edible salsify (*Tragopogon porrifolius)* with the common weedy salsify (*T. dubius*) found in our region. The weedy species has a yellow flower while the edible salsify's flower is purple. The species will cross, though!

Planting and Care: Because of its long season, be sure to fertilize salsify prior to planting and side-dress when you thin the plants. A deep, sandy loam soil is preferred for ease of harvest. Any check in growth can cause the roots to become woody, so try to keep the plants growing vigorously.

Harvesting: Dig the roots in late fall, or you may mulch them and dig them through the winter if your ground doesn't freeze solid. They'll become sweeter after exposure to cold. Store roots as you would parsnips.

There aren't many varieties to choose from. Try 'Mammoth Sandwich Island', a 120-day heirloom variety with white flesh and off-white skin.

Fun Fact

Salsify is a native of the Mediterranean area and a relatively obscure member of the Sunflower family. We know the wild plant was eaten by Saint Albertus Magnus in the thirteenth century, but salsify was not actually cultivated until about 1600. It was grown widely in France by 1612 and was brought to America in the late 1700s when Thomas Jefferson grew it in his garden.

Shallots

Allium cepa (Aggregatum group)
Family: Amaryllis / Amaryllidaceae (formerly Alliaceae)

Direct Seed or Transplant: Transplant sets
Optimum Range of Soil Temperature for Planting: 55–75°F
Minimum Soil Temperature for Planting: 45°F
Set Planting Depth: 3/4 of their length deep
Days to Maturity: 80–100
Set Spacing within Row: 4–8"
Depth of Root System: Shallow
Distance between Rows: 36–48"
Consumption of Nitrogen: High
Ease of Transplant: Easy
Average Yield per 10' Row: Variable

Shallots are perennial plants native to western Asia that are grown as annuals for their cluster of bulblets or cloves. They may also be used as green onions.

Fun Fact

Shallots were probably introduced into Europe by returning Crusaders in the twelfth and thirteenth centuries. The French had introduced shallots into New Orleans by 1800.

Planting and Care: Shallot sets are planted in early spring and grown as a summer crop in our region, where their green tops may be harvested anytime they're ready. Dry bulbs are harvested about 60–100 days after planting. Grow shallots as you would onions.

What Happened Here?

My bulbs are very small. They didn't receive enough water or fertilizer or there were too many weeds during bulb formation. The plants may also have been crowded.

Harvesting: To harvest as "green onions," blanch the stems if you would like a mild flavor. Mound the soil about 2" deep around the plants about 2 months prior to harvest. Wait 2 weeks, and then mound soil another 2" deep. Pull plants when the tops are 6–8" tall.

For dry bulbs, harvest when the tops have fallen over and cure as you would onions.

Suggested Shallot Varieties

Variety	Days to maturity	Comments
Pikant	80	Brown skin; red flesh
Ambition	100	Red skin; long storage
Zebrune	100	Brownish-pink skin; torpedo shape

Spinach

Spinacia oleracea
Family: Goosefoot / Amaranthaceae (formerly Chenopodiaceae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 45–75°F
Minimum Soil Temperature for Germination: 35°F
Seed Planting Depth: ¼"
Days to Maturity: 37–45
Seed Spacing within Row: 1"
Depth of Root System: Shallow
Thinned Spacing within Row: 2–6"
Consumption of Nitrogen: Moderate
Distance between Rows: 12–36"
Average Yield per 10' Row: 4 lb.

There are two types of spinach leaves. Savoy-type spinach has very crinkly and thick leaves with good tooth appeal. Unfortunately, the crinkly nature of savoy-type leaves holds more soil, making careful washing necessary. For this reason, some gardeners prefer to plant the smooth-leaf spinach.

Spinach is an annual plant that forms a rosette of leaves when grown under cool conditions, but in the long days and high temperatures of summer it will quickly bolt. It is shallow rooted, with most of its roots within the top 2" of the soil.

Fun Fact

This native to central Asia was first cultivated by the Arabs. The plant spread into China, where it was being cultivated by the seventh century. The Moors carried it into Spain around AD 1000, and from there it had spread into the rest of Europe by the fourteenth century. It was not widely grown in northern Europe until the eighteenth century. Its use on church fast days was first recorded in 1351, and it graced the table of King Richard II in 1390. Its precise date of introduction into the United States is not known, but it was common here by 1800.

This hardy crop withstands light freezes to 20°F, though it makes its best growth at temperatures of 60–65°F and is intolerant of temperatures above 77°F. It is grown as a spring and fall crop in the Rocky Mountains.

Planting and Care: For baby spinach, sow seeds as close as 3/4" apart and snip the plants, leaving 1" or so of stem, as they get to your perfect size. Plants will regrow and give you several harvests of delicious greens. Sow seeds for fall crops about 6 weeks before the first frost. Plants are usually ready to begin thinning and harvesting within 21–35 days after planting.

Spinach does well on most soils, but plants grown in soil with a pH above 6.5 may become yellow, and, if soil pH is lower than 5.5, plants will be severely stunted.

This crop does best with high fertility, so spread manure in the fall prior to spring planting and turn under a green manure crop as well. Broadcast some fertilizer before planting and side-dress when

the plants are a few inches high.

Keep the soil uniformly moist with a soaker hose to avoid wetting the foliage. Spinach is very susceptible to air pollution injury. Both ozone and sulfur dioxide will cause the leaf edges to die, as well as leaf speckling to occur.

Harvesting: If you want large, uniform plants, thin them to stand about 4–6" apart in the row. If you care only for the greens and not the shape or size of the plants, don't bother. Instead, thin by harvesting the largest plants for dinner and let the smaller ones grow. You may harvest single leaves or entire plants. Begin to harvest your crop when it has developed 5 or 6 leaves and continue until just before it bolts, cutting the plants at the soil line.

What Happened Here?

My spinach plants grow tall and flower before the harvest is over. Spinach bolts in warm weather. You can try planting earlier in the spring or later in the season for a fall crop.

The leaves have tunnels in them. Leaf-miner adults are small flies that lay their eggs on the underside of leaves. The maggots hatch and burrow between the upper and lower surfaces of the leaves. Try placing row covers at planting to prevent the adults from laying eggs. Pick and remove heavily infested leaves from your garden. Tear out small tunneled areas and eat the rest of the leaf.

Suggested Spinach Varieties

Variety	Days to maturity	Comments
Melody	42	1977 AAS Selection; most popular savoy type; low bolting susceptibility
Space	39	Tried-and-true variety; smooth to slightly savoyed leaves
Bloomsdale Longstanding	48	Heirloom; holds quality; smooth leaf; low bolting susceptibility
Tyee	40	Bolt-resistant; savoy type

Squash, Summer

Cucurbita pepo
Family: Gourd / Cucurbitaceae

Direct Seed or Transplant: Either, but usually direct seeded
Optimum Range of Soil Temperature for Germination: 70–95˚F
Minimum Soil Temperature for Germination: 60˚F
Optimum Range of Soil Temperature for Planting: 65–75˚F
Minimum Soil Temperature for Planting: 60˚F
Seed Planting Depth: ½–1"
Days to Maturity: 40–50
Seed Spacing within Row: 12" (plants); 48" (hills)
Depth of Root System: Moderate
Consumption of Nitrogen: Moderate
Thinned Spacing within Row: 24–36" (see text)
Average Yield per 10' Row: 20 lb.
Distance between Rows: 36–48" (see text)
Ease of Transplant: Requires special care

Grow Your Own Transplants

Optimum Soil Temperature for Indoor Germination: 90˚F
Approximate Length of Germination Period: 6–10 days
Approximate Time to Grow to Transplant Size: 4–5 weeks

Squash do better in cooler climates than cucumbers and melons. Summer squashes need only about 40–60 days to produce a crop and are eaten in an immature stage before their rinds harden.

Fun Fact

Squash belong to 4 species—Cucurbita pepo, C. maxima, C. moschata, and C. argyrosperma—*all originating in the area from the southwestern United States to South America's Andes mountains. All squash have fine-grained flesh, and summer squash is eaten as a vegetable with meals. Summer squash mature in a relatively short season but stores poorly.*

Dry, sunny weather is important for good pollination, though drought conditions reduce fruit set. Most summer squash form bushy plants that are easy to control.

All squash plants are monoecious, bearing separate male and female flowers in the ratio of about 3 female to 1 male. The male flowers appear first in the season and are often stuffed and cooked. Plants within a species intercross, and certain species will cross with other species. For example, plants in *C. moschata* will cross with those in *C. pepo* and *C. argyrosperma*. Don't worry about strange fruit unless you save the seeds for planting the following season. See the winter squash entry for a table on squash intercrosses.

Planting and Care: Be sure the soil has warmed to at least 60°F (warmer is better) before planting. Drop several seeds into a group (also called a "hill") and thin to 2 or 3 plants when they have formed their first leaves. Squash are best thinned by pinching out unwanted plants rather than pulling them out if sown close together. You can also transplant squash to the garden. Space hills 48" apart.

What Happened Here?

I have wonderful looking squash vines, but few fruit. This

is probably due to poor pollination, but don’t forget that male flowers won’t produce fruit, and they typically appear first.

My squash vines grew well, then suddenly wilted. Look for a little hole with sawdust-like material in the stem at the soil line. If you find one, slit the stem lengthwise with a razor blade, passing through the hole and cutting the worm—a squash vine borer. Mound soil over the slit and the plant will root at that spot.

Squash are heavy feeders. They do well in soil supplied with high amounts of organic matter and moisture; incorporate a spadeful of rotted manure or compost to each hill at planting. Broadcast preplant fertilizer and side-dress when the first flowers bloom.

You must supply plenty of moisture to summer squash with watering cans or soaker hoses; wetting the foliage with sprinklers encourages diseases.

Suggested Summer Squash Varieties

Variety	Days to maturity	Comments
Safari	50	Zucchini type; green with white stripes
Raven	48	Zucchini type; very dark green fruit
Multipik	50	Yellow straightneck; good producer of male flowers for stuffing
Early Prolific Straightneck	50	1938 AAS Selection; heirloom; yellow; heavy yields
Yellowfin	50	Golden zucchini; powdery mildew resistant
Sunburst hybrid	50	Patty pan type; high yield
Zephyr	54	Crookneck; half yellow, half light-green fruit
Early White Bush Scallop	46	Heirloom; patty pan type
Alexandria	48	Light-green skin; Mideast-type zucchini

Summer squash come in many colors and shapes, and just about any variety will be successful in your garden. Most commonly, fruit are green, yellow, or white and are round and flat (patty pan),

straight (straight-necked), club-shaped (zucchini), or curved (crooknecked).

Harvesting: Pick summer squash 2–8 days after bloom (40–60 days after planting) when the fruit is 4–8" long, 2" in diameter (3–4" in diameter for patty pan squash), and the rind is still soft. Never let the fruit mature on the vine as doing so signals the plant to stop flowering. Besides, mature summer squash are seedy and lousy to eat, unless you intend to stuff them. If you can’t use all the squash, give some to your neighbors until you try their patience.

Squash, Winter and Pumpkin

Cucurbita spp.
Family: Gourd / Cucurbitaceae

Direct Seed or Transplant: Either
Optimum Range of Soil Temperature for Germination: 70–95˚F
Minimum Soil Temperature for Germination: 60˚F
Optimum Range of Soil Temperature for Planting: 65–75˚F
Minimum Soil Temperature for Planting: 60˚F
Seed Planting Depth: ½–1"
Days to Maturity: 85–110
Seed Spacing within Row: 12" (plants); 48" (hills)
Depth of Root System: Deep
Consumption of Nitrogen: Heavy
Thinned Spacing within Row: 24–36"
Average Yield per 10' Row: 20 lb.
Distance between Rows: 7–10'

Grow Your Own Transplants

Optimum Soil Temperature for Indoor Germination: 90˚F
Approximate Length of Germination Period: 6–10 days
Approximate Time to Grow to Transplant Size: 4–5 weeks
See the entry on summer squash for more information on the culture of squash.

Winter squash and pumpkins require a long, warm season of 80–140 days. Dry, sunny weather is important for good pollination, though drought conditions can reduce fruit set.

Most winter squash and pumpkin plants are vines, though some bush types are available. All squash bear separate male and female flowers in the ratio of about 3 female to 1 male, with male flowers appearing first. Plants within a species intercross, and certain species will cross with other species. Melons and cucumbers will not cross with squash and pumpkins. Don’t worry about it unless you save seeds.

Some Commonly Grown Cucurbit Varieties and Their Species

Note: Varieties within the same species will cross freely, as will varieties within species with the same superscript.

Cucurbita pepo[a]	*Cucurbita moschata*[a,b]	*Cucurbita maxima*[b]	*Cucurbita argyrosperma*[a]
Pumpkin: Baby Boo, Baby Pam, Big Red California Sugar, Big Tom, Caserta, Cheyenne Bush, Cinderella, Connecticut Field, Cow, Happy Jack, Halloween, Howden, Jack-Be-Little, Jack O'Lantern, Lady Godiva, New England Pie, Pankow	**Pumpkin:** Cheese, Dickinson, Kentucky Field, Long Island, Longfellow, Quaker Pie, Tennessee Sweet Potato	**Pumpkin:** Amish Pie, Atlantic Giant, Big Max, Big Moon, Burgess Giant, German Sweet Potato, Harvest Moon, King of Mammoths	**Pumpkin:** Green Striped Cushaw, Jonathan, Pennsylvania Crookneck, White Cushaw, White Crookneck
Squash: Acorn, Cocozelle, Crookneck, Delicata, Patty Pan, Spaghetti, Straightneck, Sweet Dumpling, Vegetable Marrow, Zucchini	**Squash:** Butternut, Golden Cushaw, Orange Cushaw, Pennsylvania Dutch Crookneck, Small Flat Cheese	**Squash:** Banana, Boston Marrow, Buttercup, Golden Delicious, Hubbard, Hokkaido, Kabocha, Lakota, Turk's Turban	**Squash:** Cushaw

(Source: Gough and Moore-Gough 2011.)

Be sure the soil has warmed to at least 60°F before planting. Plant seeds of the bush or small vine-forming varieties about 2' apart in rows about 5' apart, but give the large vine varieties at least

3' within rows spaced 7–9' apart. Drop several seeds into the hill and thin to 2 or 3 plants when they have formed their first leaves. You can also transplant squash to the garden to get a jump on the season.

Winter squash and pumpkins do well when supplied with high amounts of organic matter and moisture, so incorporate a spadeful of rotted manure or compost to each hill. Broadcast preplant fertilizer and side-dress when the plants begin to run (vine types), or when the first flowers open (bush types).

You must supply plenty of moisture to squash with watering cans or soaker hoses; wetting the foliage with sprinklers will only encourage diseases.

Breeders have worked hard to adapt squash to today’s gardens and families. Both are generally smaller than those of our grandparents as there is often no room for large vines and no need for large fruit. For example, the large fruit of the ‘Hubbard’ have been shrunk to manageable size.

Pumpkins are typically round and orange, and winter squash are often green, golden, or buff-colored and more or less globe shaped or cylindrical. Like summer squash, there are several main types of winter squash. Hubbard types have the typical ‘Hubbard’ shape and

may be blue-green or golden and standard sized (up to 50 pounds) or dwarf (several pounds). Delicious types resemble ‘Butternut’ squash with long, curved necks. Acorn squash form bushy plants with acorn-shaped fruit that may be deep green, white, or golden. Buttercup squash actually look more like acorns than the acorn squash and come complete with the “cap.” Everyone knows what the buff-colored butternut squash looks like. The flesh of these holds its firmness in stews and in steaks for vegetarians.

Fun Fact

Winter squash, pumpkin, and summer squash originated in the area from the southwestern United States to South America’s Andes mountains. Columbus brought specimens to Europe, and noted the native peoples’ practice of allowing vines to climb cornstalks and trees. Pumpkins and squashes are botanically inseparable and vary only by cultural methods, use, and flavor. Winter squash have mild, fine-grained flesh and are eaten in pies or as vegetables with meals. Pumpkins are primarily used for stock feed and for decorations. They have orange rinds and stronger-flavored, coarse flesh. Commercially prepared “pumpkin pie” filling is actually made from squash.

Pumpkins are traditionally large and orange but also are available as large white-fruited types and as miniature orange- and white-fruited types.

Harvesting: Harvest pumpkins and winter squash when they are fully mature (80–140 days after planting) and a deep color. The fruit rinds should be so hard that your fingernail cannot puncture them. Harvest them before a frost since even a slight freeze will damage the fruit. Butternut types are especially sensitive to chilling at temperatures of 35–45°F. Cut them and other squash from the vine, leaving a 2" piece of stem (a handle) attached to the fruit. Cure before storage by placing fruits under cover at 80°F for 10 days. This aids in sealing wounds in the rind. Then, remove them to a dry room at 50°F and about 60 percent relative humidity where they will keep for several months, depending upon type.

What Happened Here?

I have wonderful looking squash vines, but few fruit. This is probably poor pollination from lack of bees or from poor

weather during bloom. Remember that male flowers appear first and will not produce fruits.

My squash vines grow well, and then suddenly wilt. Look for a hole filled with sawdust-like material in the stem where the plant leaves the ground. Slit the stem lengthwise, passing through the hole and the small worm that made it.

Suggested Winter Squash Varieties

Variety	Days to maturity	Comments
Blue Hubbard	100	Heirloom; standard large Hubbard type; 12–15 lb. fruit
Baby Blue Hubbard	95	Small Hubbard type; 4–6 lb. fruit
Golden Delicious	100	Heirloom; delicious type; 7–9 lb.
Table Ace	85	Bush acorn type
Table Queen	80	Heirloom; bush acorn type
Bonbon Buttercup	81	2005 AAS Winner; space saver; small fruits
Sweet Mama	95	1979 AAS Selection; buttercup type
Waltham Butternut	105	1970 AAS Selection; large-fruited standard type; 3–4 lb. fruit
Connecticut Field Pumpkin	120	Heirloom; 20 lb. orange fruit
Lumina	100	White pumpkin; 10–15 lb.
Baby Boo	95	Miniature white pumpkin
Lady Godiva	105	Heirloom pumpkin with hulless seeds for eating raw or roasted
Big Max	120	Giant pumpkin; 100 lb. fruit
Omaha	80	Collected from Omaha Indians; 3–5 lb. fruit

Swiss Chard

Beta vulgaris var. *cicla*
Family: Goosefoot / Amaranthaceae (formerly Chenopodiaceae)

Direct Seed or Transplant: Either
Optimum Range of Soil Temperature for Germination: 50–85°F
Minimum Soil Temperature for Germination: 40°F
Optimum Range of Soil Temperature for Transplanting: 60–65°F
Minimum Soil Temperature for Transplanting: 40°F
Seed Planting Depth: ½"
Days to Maturity: 50–60
Seed Spacing within Row: 2"
Depth of Root System: Moderate to deep
Thinned Spacing within Row: 4–12"
Distance between Rows: 24–36"
Consumption of Nitrogen: Moderate
Ease of Transplant: Easy
Average Yield per 10' Row: 5 plants

This cool-season crop tolerates high temperatures better than other greens and is grown through the summer in our region. Grow it as you would beets.

Fun Fact

Swiss chard is a beet grown for its tops and does not develop a swollen root. Aristotle and Theophrastus described several varieties in the fourth century BC, and Pliny described one grown for its thick stems.

Planting and Care: You can easily transplant chard as soon as the danger of hard frost has passed, but there is really no need to do so. Most gardeners direct seed it. Thin the young plants to stand about 4" apart at first, then 10" apart as they begin to crowd. Transplant the thinnings or use them as tender greens. If you plan to use the Swiss chard leaves only when they're small, keep the plants at closer spacings; if you want larger plants and leaves, thin plants to stand farther apart.

Spring-planted chard lasts through the summer and well into fall. It is adaptable to soil types so long as they are fertile and well drained, but it does respond well to large amounts of organic matter. Broadcast preplant fertilizer and side-dress at least once if you plan on carrying the plants into the fall.

Regular Swiss chard varieties have thick, dark-green crumpled leaves and green-white leaf stalks, though some interesting varieties have brilliantly colored or multicolored stalks.

Harvesting: Harvest by removing the outer stalks over time about 1–2" above the soil line, by cutting all plant stalks about 2" above the soil line (allowing the plant to completely regrow), or the entire plant at the soil line. If you take care not to damage the small bud at the center of the plant, it will continue to produce new leaves until fall. Swiss chard freezes very well and maintains its wonderful flavor.

Suggested Swiss Chard Varieties

Variety	Days to maturity	Comments
Fordhook Giant	60	Heirloom; thick white stalks
Five Color Silverbeet	55	Heirloom; multicolored stalks
Bright Lights	60	1998 AAS Selection; hybrid, multicolored stalks
Rhubarb Red	60	Heirloom; bright red stalks

Tomato

Solanum lycopersicon
Family: Potato or nightshade / Solanaceae

Direct Seed or Transplant: Either, but usually transplant
Optimum Range of Soil Temperature for Germination: 60–85°F
Minimum Soil Temperature for Germination: 50°F
Optimum Range of Soil Temperature for Planting: 70–75°F
Minimum Soil Temperature for Planting: 65°F
Seed Planting Depth: ¼–½"
Days to Maturity: 60–90
Seed Spacing within Row: 12–24"
Depth of Root System: Deep
Thinned Spacing within Row: 18–24" (staked)
Consumption of Nitrogen: Moderate
Distance between Rows: 36–60"
Average Yield per 10' Row: 15 lb.
Ease of Transplant: Easy

Grow Your Own Transplants
Optimum Range of Soil Temperature for Indoor Germination: 70–75°F
Approximate Length of Germination Period: 4–9 days
Approximate Time to Grow to Transplant Size: 5–6 weeks

The tomato requires a growing season of 60–120 days from transplant. Daytime temperatures of about 70°F are best. The plant stops growing at temperatures above 95°F and below 53°F and is killed by long exposure to temperatures below 50°F. Plants require ample water throughout the season, but cold water droplets falling on the surface of warm ripening fruit can cause cracking.

Tomato plants have 3 growth habits in varying degrees: indeterminate, determinate, and semi-determinate. A *determinate* plant produces several flower clusters, each separated by a leaf or 2, then terminates with a flower cluster. This results in many side branches. The growth of each side branch is similar to that of the main stem. This gives a compact plant with a concentrated period of fruit ripening. For ease of harvest, you can use a tomato cage for determinate types.

Plants with the *indeterminate* habit have a central shoot that continues to grow throughout the season. Side shoots are short with few branches. Flower clusters, usually separated by 3 or 4 leaves, are produced along the vine. Fruit produced on older, lower clusters ripen first, followed by fruit on progressively younger clusters. The vine sprawls or can be trellised, and the fruit ripen over a long period of time.

Semi-determinate types have characteristics intermediate between the others. They may have several lateral flower clusters with the main stem ending in a flower cluster as well.

Tomato flower clusters develop directly from the stems and not in the leaf axils. The flowers are borne in groups called "inflorescences," each having 4–12 or more flowers. Fruit develop after pollination but development on the plant is uneven because all flowers are not pollinated at the same time.

Fun Fact

Tomatoes probably originated in the Andes mountains of Bolivia and Peru, and the Aztecs and Incas developed these into today's large-fruited forms.

Early European explorers carried seeds to Italy, where the plants had gained notice by 1544, and whence it spread into France, Germany, and

other continental countries by 1600. The French and the southern Italians relished it, but the British thought it poisonous, probably because of its relationship to belladonna. This prejudice carried over into the American colonies. While the tomato was grown in the Carolinas and Georgia in the early 1700s and even had its virtues extolled by Thomas Jefferson in 1781, the plant was not generally cultivated in the United States until 1835. It was not until the latter part of the nineteenth century that it came under extensive commercial cultivation. 'Mikado' tomato was the first commercially available hybrid vegetable (in 1882).

Optimum pollination temperatures are between 60°F and 70°F. Daytime temperatures above 85°F and nighttime temperatures above 70°F or below 55°F during bloom reduce fruit set. Low humidity, wind, excess nitrogen, insufficient light, and drought cause flowers to abort.

Planting and Care: Most of the gardeners in our region transplant their tomatoes. Good tomato sets should be 6–8" tall and have stocky, pencil-thick stems with 4–6 dark green leaves. Plants properly hardened have a slight purpling on the stem and the leaf veins.

Tomato sets that have become too tall dry out rapidly and may blow over if planted at the usual depth. Instead, plant them deeply or dig a small trench within the row and lay their stems along the bottom with the top several inches of the plant aboveground. Fill the trench and roots will sprout along the buried stem. When planting deeply, pinch off any leaves that would be buried to reduce the chances of rot. Don't plant tomato transplants that are in bloom or that have small fruit, for their growth will be slow and the plants will produce poorly.

Tomatoes respond well to moderately high fertility, but excess nitrogen delays maturity and results in "vinyness" and too many small green fruit. Broadcast fertilizer just before planting and side-dress when plants have become established and again after they have set several fruit. Don't fertilize again.

Plants under water stress during early development may never recover, and plants that receive insufficient water during bloom may develop blossom-end rot.

Sprinklers are satisfactory for watering during the first half of the plant's development, and they won't knock off the flowers as some people believe. During the second half of development, use soaker hoses as wetting the fruit during ripening can crack them.

Red plastic mulch is ideal for tomato plants and promotes earlier maturity. Straw mulch or grass clippings are also fine but may slow growth in cooler soils.

Tomato plants will trail along the ground unless they're supported. Sprawling vines bear the most fruit, but they ripen later and are more damage prone. If you decide to let them sprawl, apply a thick layer of straw mulch around the plants to keep the fruit off the ground.

Pinch out suckers to control excess bushy growth.

Supports increase the yield of good fruit, make picking easier, save space, and reduce the chance of stepping on vines. The most

common method is to drive a 6' stake 2' into the ground 3–4" from the plant at transplanting. When plants have reached 12–15" in height, prune them to 2 or 3 stems by pinching off the lateral stems as they appear in the leaf axils. Continue to pinch out these “suckers” to avoid overgrowth of flowering stems producing fruit that won’t ripen. Fruit on pruned plants can ripen up to 14 days earlier than those on nonpruned plants, though pruned plants won’t bear as many fruits, and their fruits may have a higher evidence of blossom-end rot. You may prune to only 1 main stem, but that leaves no security for the crop should that stem be injured. Tie the stems loosely to the stake with soft twine. Knot the twine tightly to the stake about 2" above a leaf stem, and then wrap it loosely around the stem just below the leaf base. As the plant grows, make new ties about every 12" along the stem.

What Happened Here?

My tomato plants look very healthy and grow tall and bushy, but produce few fruit that never ripen. You might be fertilizing with too much nitrogen, watering too much, or the nights might be too hot. Pinch the terminal shoots and decrease the watering and fertilizing.

My tomato plants took forever to begin growing. Tomato plants will not grow when night temperatures fall into the 50s°F; planting them early will not necessarily give you an earlier crop, so don’t jump the gun.

My tomato plants’ blossoms drop off before producing fruit. This is common on cool nights when the temperatures fall into the 50s°F or when night temperatures remain in the mid-80s°F.

You can buy tomato cages or make them yourself from 4'-wide lengths of 4" x 6"-mesh stock fencing or concrete reinforcing wire. A piece 5' long will make a cage about 18" in diameter. Vinyl-covered wire and plastic cages resist rust. Set the cage over the young tomato plants and tie it to four 4' stakes driven into the ground. Fruit on caged plants ripen later but are more perfectly shaped than those on staked plants.

Tomato varieties vary according to vine habit, fruit color, size,

shape, season of ripening, the area of the country to which they are adapted, and pest resistance, but can be subdivided into types according to their uses and characteristics.

Beefsteak: There is a variety called 'Beefsteak', but the term is generally applied to any large tomato that has thick, solid flesh with few seed cavities. Most of these require long seasons (about 100 days) to ripen their fruit and are not well adapted to our region.

Container: Although any tomato plant can be grown in a container, varieties that produce small fruit less than 2" in diameter on plants less than 24" tall are best suited to this method.

Main Crop: This type produces medium to large fruit with varying days to maturity. Most common varieties are of this type.

Paste: Fruit of these contain less water and more meat and are used for paste, canning, and catsup. They are also wonderful to eat out of hand.

Salad: These are "cherry" tomatoes with fruit up to 1½" in diameter.

Tomatoes get several physiological disorders. Blossom-end rot is the result of tissue breakdown near the blossom end of the fruit characterized by a sunken, dark-brown leathery spot that enlarges as the fruit matures. It is caused by a calcium deficiency in the fruit that is aggravated by fluctuations in soil moisture, excessive nitrogen fertilization, and root damage. Ironically, tests may indicate adequate calcium in the soil. In this case inconsistent watering may be the problem as calcium moves with water into the plant. It's more of a problem on staked or pruned plants and those that have not been mulched.

Catfacing is most likely to occur on early ripening fruit when the faded blossom sticks to the fruit tissue during cool, cloudy weather, causing the blossom end to become malformed.

Suggested Tomato Varieties

Variety	Days to maturity	Comments
Brandywine	78	Heirloom; pink fruit; indeterminate
Better Boy	75	Red 10 oz. fruits; indeterminate
Early Girl	59	Main crop; indeterminate
Black Sea Man	75	Heirloom; determinate; large, ugly, pinkish-brown fruits are rich-tasting
Celebrity	67	1984 AAS Selection; main crop; heavy yield; determinate
Fourth of July Hybrid	49	Early-ripening 4 oz. fruits; indeterminate
Roma	76	Heirloom; classic red paste type; determinate
Golden Mama	68	Paste type; yellow; indeterminate
Super Sweet 100	65	Cherry type; indeterminate
Gold Nugget	56	Cherry type; yellow, very sweet; determinate
Sun Gold	57	Cherry type; orange; extra sweet; indeterminate
Indigo Rose	75	1–2 oz. purple-red fruits; indeterminate

Sunscald occurs when green fruits are exposed to direct sun. This causes a greenish-white patch to develop on the exposed shoulder and is most apt to occur on fruit of pruned or partially

defoliated plants.

Growth cracks occur when the fruit skin cannot stretch fast enough to accommodate growth. This results from extreme changes in fruit growth rate due to large and sudden moisture fluctuations and temperatures above 90°F. Radial cracking begins at the stem end and radiates out over the fruit surface. Concentric cracking occurs in concentric circles around the stem end of the fruit. Never water tomatoes heavily following an extended drought, and never sprinkle water onto the surface of maturing fruit. If you’ve had this problem, plant crack-resistant varieties.

Harvesting: Tomato fruits ripen 6–8 weeks after bloom. Keep this in mind when dealing with your short growing season! If the flowers have no chance of producing a ripe tomato, pull them off to encourage the plant to ripen fruit that will most likely ripen. The lowest temperature at which they will ripen properly is 55°F, though the optimum temperature is 68°F. Even a brief exposure of green fruit to 40°F destroys the enzyme responsible for proper ripening. Temperatures above 80°F inhibit the development of red color, and otherwise “red” fruit turn yellow-orange. Leave fruit on the vine until they are fully ripe and just begin to soften. If temperatures are expected to remain above 80°F or if frost is expected, harvest the fruit when they begin to develop mature color and ripen them indoors at about 70°F.

Turnip

Brassica rapa (Rapifera group)
Family: Mustard / Brassicaceae (formerly Cruciferae)

Direct Seed or Transplant: Direct seed
Optimum Range of Soil Temperature for Germination: 60–105°F
Minimum Soil Temperature for Germination: 40°F
Seed Planting Depth: ¼–½"
Days to Maturity: 40–75
Seed Spacing within Row: ½–1"
Depth of Root System: Moderate
Thinned Spacing within Row: 2–6"
Consumption of Nitrogen: High
Distance between Rows: 12–36"
Average Yield per 10' Row: 5 lb.

Like rutabaga, the turnip is grown for its large tasty root, and both have varieties with yellow and white flesh. The 2 vegetables have similar cultural requirements. Turnip roots may be round, elongated, or conic in shape, and are slightly flattened. The greens sprout directly from the root, which are usually white to tan with purple near their top. Turnips may also have green or bronze skin. The leaves are hairy, thin, and green.

Fun Fact

The turnip has been used for food since prehistoric times and grows wild in Siberia. The Romans grew it for its leaves and enlarged root and later introduced the plant into other parts of Europe, where it was widely grown in France during the Middle Ages. It was introduced into England in the middle of the sixteenth century. Turnips were brought to Canada in 1540 by French explorer Jacques Cartier and were cultivated in Virginia by 1609. The turnip is slowly being replaced on American tables by the tastier potato and by its close relative the rutabaga, which has higher nutritional value.

Planting and Care: Turnips tolerate low temperatures, and you must time planting so the roots mature during cool weather; roots get bitter and woody in hot weather, but prolonged exposure of young plants to 50–55°F will cause them to bolt.

Plant turnips as a spring or fall crop, but the fall crop usually has better flavor. Spring crops usually need fairly high fertility to mature before warm weather hits. Broadcast fertilizer before planting and side-dress your plants when you thin them. High fertility is not so important for the fall crop as the weather cools and plant growth slows. Turnips are sensitive to boron deficiency, but before adding boron, have your soil boron levels tested and watch for brown heart, an indicator of low boron.

Brown heart is a browning and breakdown of flesh at the center of the root that typically shows up in warm weather when the plants are growing rapidly. It can be corrected for your next crop by adding borax to the soil, but there is a fine line between not having enough boron and having too much! Excessive levels of boron will sterilize your soil.

What Happened Here?

The root core is brown. This is typically caused by a boron

deficiency. Have your soil professionally tested and follow the lab's instructions for amendments.

There are shot holes in the leaves. These are usually caused by flea beetles, small (1/16"), usually dark-colored beetles that travel on the wind. Row covers applied at planting are effective in protecting your garden.

My turnips have tunnels in their roots. Root maggots cause damage to many root crops. They overwinter in the soil, so rotate your crops next year and don't plant susceptible vegetables in that spot. The adult of the root maggot is a flying insect, and may be excluded from an uninfested location with the use of row covers at planting. Row covers will not help if they are placed over an area where the root maggot has overwintered.

Always follow the recommendations of a professional soil-testing lab before applying any boron-containing compound to your soil.
Harvesting: Turnip roots are tastiest when they are 2–3" in diameter and mature in cool weather. Harvest the entire crop before the weather gets too hot. If you're growing turnips for greens, harvest them about 4–6 weeks after planting.

Suggested Turnip Varieties

Variety	Days to Maturity	Comments
Purple Top White Globe	55	Heirloom; nicely shaped; excellent for fresh or winter storage; white-fleshed roots
Shogoin	70	Heirloom; grown for leaves and large roots
Tokyo Cross Hybrid	35	Early yielding; disease resistant

Watermelon

Citrullus lanatus
Family: Gourd / Cucurbitaceae

Direct Seed or Transplant: Transplant
Optimum Range of Soil Temperature for Planting: 70–85˚F
Minimum Soil Temperature for Planting: 65˚F
Transplant Spacing within Row: 24–36"
Days to Maturity: 75–95
Distance between Rows: 72–96"
Depth of Root System: Deep
Ease of Transplant: Requires special care
Consumption of Nitrogen: Heavy
Average Yield per 10' Row: 7 melons

Grow Your Own Transplants

Optimum Range of Soil Temperature for Germination: 80–90˚F
Approximate Length of Germination Period: 3–12 days
Approximate Time to Grow to Transplant Size: 4 weeks

Watermelon seedlings are damaged very easily. Young plants will be set back by any frost or cultivation damage during their first week of growth. Vine growth is upright at first, but after the first 6 leaves have formed, the plants lie down and begin to run.

Fun Fact

Watermelons are heat-loving, long-season members of the same family as muskmelons. They are thought to have originated in Africa, where, in the nineteenth century, the famous explorer Dr. David Livingstone discovered fields of wild melons. They were also reported by European settlers in the United States as being grown in the Illinois River Valley by Native Americans in the early 1600s. Since it is fairly unlikely the watermelon originated in the Americas, perhaps the "Indian melon" was actually a native citron and not a watermelon.

As in cucumbers, watermelons are monoecious, meaning they have distinct male and female flowers; the male flowers are the first to bloom, followed by the female flowers several days later. Watermelon plants usually bear only 1 or 2 good-sized fruit.

Planting and Care: Set each transplant at the indicated spacing above and, if you use peat pots, be sure to plant the entire pot containing the plant. Do not remove the plants from the pots, since any damage to their root system may doom your crop.

Watermelons should receive enough fertilizer to sustain uninterrupted growth throughout the season. Good vine growth is important to supply sugar to the fruit. Apply a preplant fertilizer and side-dress the plants just before they begin to run.

Watermelons are more drought tolerant than muskmelons, but all melons should receive plenty of water throughout their season. Water is especially critical during fruit set and growth. Avoid wetting the foliage by using drip irrigation whenever possible. All melons are highly susceptible to both powdery and downy mildews, which destroy the leaves and leave your melons bitter or tasteless.

What Happened Here?

The blossoms on my watermelons drop, and no fruit sets.

Like cucumbers, the first flowers that appear are male and therefore do not set fruit. Wait.

Melons do a fine job of weed control once they begin to run, but until that time, it's up to you to keep weeds away. Allow the soil to warm prior to placing mulches. Use plastic row covers to increase both your early and total yields (see chapter 11 for more information on row covers).

Northern and high elevation gardeners should try the "icebox" types of watermelons. These are small (about 10 pounds) and round and require only 70–80 days to ripen their fruit.

Most seedless watermelons require a longer growing season, and gardeners in our region will have to start their plants early. You'll also have to plant a "normal" variety alongside the seedless plants for pollination. Seedless watermelons are not always completely seedless, and some seeds may form under stressful conditions.

Harvesting: Watermelon fruit matures about 10 weeks after pollination. When fully mature, muskmelon fruits separate from their stems, but watermelons do not. There are a number of indicators to use to tell when watermelons are ripe. First, check the ground spot, which is the portion of the fruit that is in contact with the ground; this will turn from white to yellow as the fruit matures. The tendril opposite the melon will turn brown or black when the fruit is ripe. And then, there's the not-so-accurate thumping test: When thumped, ripe melons give a dull thud instead of the higher pitched, almost metallic sound of unripe melons. The thumping sound is highly subjective, though, so consider thumping last. Ripe melons will be brightly colored, juicy, and have a sugar content of about 14 percent.

Suggested Watermelon Varieties

Variety	Days to maturity	Comments
Sugar Baby	76	Icebox type
Yellow Baby	70–80	1975 AAS Selection; icebox type
Golden Midget	70	Small 3 lb. fruit; skin turns yellow when ripe
Arikara	80	Heirloom; personal size; open-pollinated; pink flesh
Moon and Stars Red	90	Heirloom; dark green-skinned fruits with small yellow "stars" and usually 1 "moon"

Glossary

AAS: All-America Selections. Plant varieties that have been tested by a network of independent judges who determined their garden performance was superior under many conditions. Visit all-americaselections.org.
Andromonoecious: Production of more male flowers than perfect flowers.
Annual plants: Plants that complete their entire life cycle in 1 year.
Apex: The growing tip of a plant part. This could be a root or shoot.
Aspect: Directional exposure (topographical).
Banding: Fertilizing technique where fertilizer, often phosphorus, is placed 2" to the side and 2" below the level of the plant or seed.
Biennial plants: Plants that require two growing seasons to complete their life cycle.
Blackheart (celery): Disorder caused by a calcium deficiency wherein the inner leaves and growing point turn black.
Blindness (cauliflower): Damage to the apex resulting in a lack of curd development. This may be caused by low temperatures during the early stages of growth, freeze damage while curd is in its early stages of development, or rodent activity.
Blocking: The cutting of media into blocks to facilitate transplanting seedlings.
Blossom-end rot (BER): A disorder caused by a calcium deficiency and often related to water movement. BER affects fruiting plants, especially tomatoes, peppers, and cucurbits, and causes the flower end of the fruit to become brown and leathery.
Bolt: Going to seed as a result of improper day length or temperatures.
Broad spectrum pesticide: Pest killer that kills a wide range of pests.
Buttoning (cauliflower): The premature formation of a small curd. No further curd expansion occurs.
Calyx: All the outer floral leaves (sepals) at the base of a flower.
Cap (eggplant): The calyx of an eggplant fruit.
Cole crops: Members of the mustard family, also known as Brassicaceae (formerly Cruciferae). These crops are also sometimes referred to as brassicas.

Come true: Seed that produces exact duplicates of the parent plants. Seed from open-pollinated plants come true. Seed from hybrid plants do not.
Cotyledon: A seed leaf of a monocot or seed leaves of a dicot. First "leaves."
Cross-pollination: The spread of pollen from one plant to the stigma of another, resulting in the production of a seed with the genetics of both parents.
Curcurbits: *See* Vine crops.
Cultivar: A cultivated variety of a plant.
Curd: The "head" of cauliflower.
Cure: The process of drying certain vegetables to promote longer storage.
Damping-off: A fungal disease causing seedling stems to collapse at the soil surface and the plant to fall over and die.
Day-neutral plant: A plant in which flowering does not depend on the day length.
Days to harvest: A number found on seed packaging that may be used to compare the earliness or lateness of harvest of the variety with other varieties. The actual days to harvest in an individual garden is based on climate, watering, fertility, and many other factors.
Determinate: Growth habit where plants stop apical growth, flower, and fruit all at once. *See* Indeterminate.
Dioecious: Plants with male and female flowers on different plants.
Ethylene: A gas that promotes ripening of fruit.
Etiolate: Stretching, usually due to lack of sufficient light.
Family: A wide grouping of related plants, usually with several genera.
Fertilizer analysis: The percentages of nitrogen, phosphorus pentoxide, and potassium oxide, or "potash," in a fertilizer blend, for example: 10-10-10.
Fertilizer equivalency: Used to determine relative quantities of two fertilizers of differing nitrogen analyses.
Fertilizer ratio: The proportion of numbers in a fertilizer analysis. For example, 5-10-10 fertilizer has a 1-2-2 ratio.
Fertilizer, slow-release: Preparations that release their nutrients over a long period of time.
Fungicide: A pesticide used to kill fungi.
Genus: A grouping of plants or animals encompassing one or more species.
Germination: The beginning of growth of a seed, spore, or other structure such as pollen.

Ground heat: Heat stored in the earth that may be trapped by row covers late in the growing season.
Ground spot: The place where melon or squash fruit skin contacts the earth. Used to determine ripeness of the fruit.
Growing season: The period of time between the last killing frost of spring and the first killing frost of fall.
Gynoecious: Plants that produce only female flowers.
Hardening off: Preparing transplants for the transition from greenhouse to outdoors. Usually consists of withholding of moisture and exposure to cooler temperatures, air movement, and sunlight.
Hardpan: An impermeable layer of soil often found under the topsoil.
Heat of respiration: The heat that is given off by ripening produce. It must be controlled during storage to delay spoilage.
Heat sink: A substance that absorbs heat and dissipates, or releases, it.
Heirloom vegetable: There are many definitions. For my purposes, it's any vegetable over 50 years old that has a documented history, usually a colorful name, and is open-pollinated.
Hill: Several seeds planted in a single hole, as in the case of squash, are said to be planted in hills. These hills are not elevated.
Hilling: Mounding soil over the bases of some plants such as leeks (for blanching), potatoes (to prevent sunburn), and corn (for support).
Hybrid: A cross of two parental types that produces a unique offspring in the next, or first filial (F1), generation. Seeds saved from a hybrid will not come true and will produce plants that may resemble one of the ancestral types.
Incipient wilt: A temporary drought-induced wilt from which a plant will recover during the cool of the night or from judicious watering. Large-leaved plants such as squash and beans may wilt during midday but recover at night. Incipient wilt will become permanent wilt if irrigation is not soon applied.
Indeterminate: Climbing, or vining varieties that typically need to be trellised or staked for support, with fruit ripening over an extended period of time. *See* Determinate.
Inoculant: Coating the seeds of some legumes, such as beans and peas, with *Rhizobium* bacteria prior to planting. The bacteria is the inoculant.
Internode: The area of stem between the nodes.
Isolation: Some vegetable plants must be isolated from each other to prevent cross pollination. This can be accomplished spatially by separating the plants by 250 feet or more or temporally by planting varieties with different bloom times.
Leaf axil: The angle formed by the junction of a leaf stem (petiole)

and plant stem.
Lodge: A plant that falls over due to rampant vegetative growth is said to lodge.
Long-day plant type: A plant wherein bulb or flower induction corresponds to exposure to a certain number of long days.
Milk stage: In sweet corn, the stage in the development of the ear wherein the kernels, when punctured, excrete a milky, very slightly viscous sap. This stage usually coincides with that of the greatest sugar accumulation in the sap.
Monoecious: A plant that has both male and female flowers. Squash is an example.
Netting: The network of corky tissue on the surface of some muskmelon varieties.
Node: The point of attachment of a leaf to a stem.
Nurse cropping: The use of one plant sown directly in the row or in very close proximity to another to assist its growth in some way.
Off-types: Plants that show traits that differ from those of their parents. For example, seeds saved and planted from a hybrid variety will produce plants that will differ significantly from their parents and thus produce off-types of plants.
Open-pollinated: A non-hybrid variety that will produce offspring true-to-type from its own seeds. Heirloom vegetables are open-pollinated.
Perennial: A plant that continues to grow, flower, and set seeds every year. Rhubarb and asparagus are perennials.
Parental type: The characteristics of its parent.
Perfect flower: Flowers that contain both male and female parts.
Permanent wilt: Drought-induced wilt from which a plant does not recover.
Phytotoxicity: Literally, “plant toxicity.” A compound applied to a plant that damages the foliage or other plant parts is said to be phytotoxic to that plant.
Pricking off: Removing crowded young transplant seedlings in the first thinning when only their seed leaves are apparent.
Rag-doll test: A way to test the viability of seeds, which are wrapped in moistened toweling and placed in a jar in a warm spot. after a week or so the toweling is unwrapped, the number of germinated seeds counted, and the germination percentage calculated.
Resistance codes: Brief letter codes for pest resistance that follow the name of variety. For example *F* following a tomato variety name indicates that variety is resistant to *Fusarium* wilt.
Rhizome: An underground stem by which some plants, as asparagus,

asexually propagate and spread.
Riciness: In cauliflower, the condition in which the curds have begun to flower and discolor to a gray or pink from overmaturity.
Root crops: Crops like carrots and parsnips grown for their fleshy roots.
Savoyed: Having crinkly or dimpled leaves, as do some spinach and some cabbage varieties.
Scape: The woody flower stalk of stiffneck garlic.
Scoville heat units: A way to express the "heat" in hot peppers based upon the amount of capsaicin they contain. The greater the amount of capsaicin, the greater the number of Scoville heat units.
Seed tape: A convenient device for planting especially small seeds. The seeds are positioned along a "tape" at proper intervals and the entire tape is laid along the row. The tape dissolves and the seedlings emerge properly spaced from one another.
Self-pollination: A process by which a variety is pollinated by its own pollen.
Sets: Transplants.
Short-day plant type: A plant that must be exposed to a certain number of short days before bulb or flower induction can occur.
Side-dress: To apply fertilizer along a row of plants or in a circle around individual plants.
Silk: In sweet corn, the elongated portions of the female flower that emerge from the ear. Each silk is attached to a kernel and each must be pollinated before the kernel can develop.
Solanine: A colorless, toxic alkaloid found in plants of the potato or nightshade (Solanaceae) family and of particular concern when present in high amounts in potato tubers that were exposed to light. The exposure causes an accumulation of chlorophyll along with that of solanine, so avoid eating large quantities of green potatoes.
Spear: The main stalk of an asparagus plant.
Spot out: In transplanting, the very young seedlings that are removed in the first thinning are replanted at wider, even spacings, or "spotted out."
Strain: A selection of a variety that displays certain desirable traits not found in the parental type. These are worthy of propagating but do not represent differences from the parental type significant enough to warrant the naming of a new variety. For example, a rust-resistant strain of variety X displays resistance to the fungus but shares all other traits with the parental, non-rust-resistant strain. It might then be labeled "variety X, rust-resistant strain" rather than take on the new name of "variety Y."

Surfactant: A compound mixed with a spray to lessen surface tension and allow for more even coverage of the plant tissue.
Tasseling: In sweet corn, the emergence of the male flower stalk, or tassel, from the top of the cornstalk.
Tilth: A soil is said to have good tilth if it is well supplied with organic matter, is light and fluffy, and is easy to till.
Tipburn: Dry brown or black area at the tip of a leaf.
Tip fill: In sweet corn, the complete development of kernels at the distal end (tip) of the ear.
True-to-type: A plant is said to be true-to-type if it displays precise characteristics of its parent.
Tuber: A swollen, underground stem and storage organ. The Irish potato is a tuber.
USDA hardiness zones: The United States Department of Agriculture (USDA) has divided North America into thirteen zones based on average minimum winter temperatures. A range of 10°F separates each zone. This term is most applicable when discussing perennial plants but can sometimes influence growing seasons indirectly, thus impacting vegetable crops.
Variety: The precise common name for a plant. In 'Straight 8' cucumber and 'Butter and Sugar' corn, 'Straight 8' and 'Butter and Sugar' are the varieties and are set off by single quotation marks. Although replaced by the more proper term *cultivar* nearly 50 years ago, the term remains commonly used.
Vine crops: Melons, squashes, cucumbers, gourds, and all members of the gourd (Cucurbitaceae) family. Also sometimes referred to as "cucurbits."
Zoning: Alternating light and dark rings that appear in the cross section of a beet root.

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About the Authors

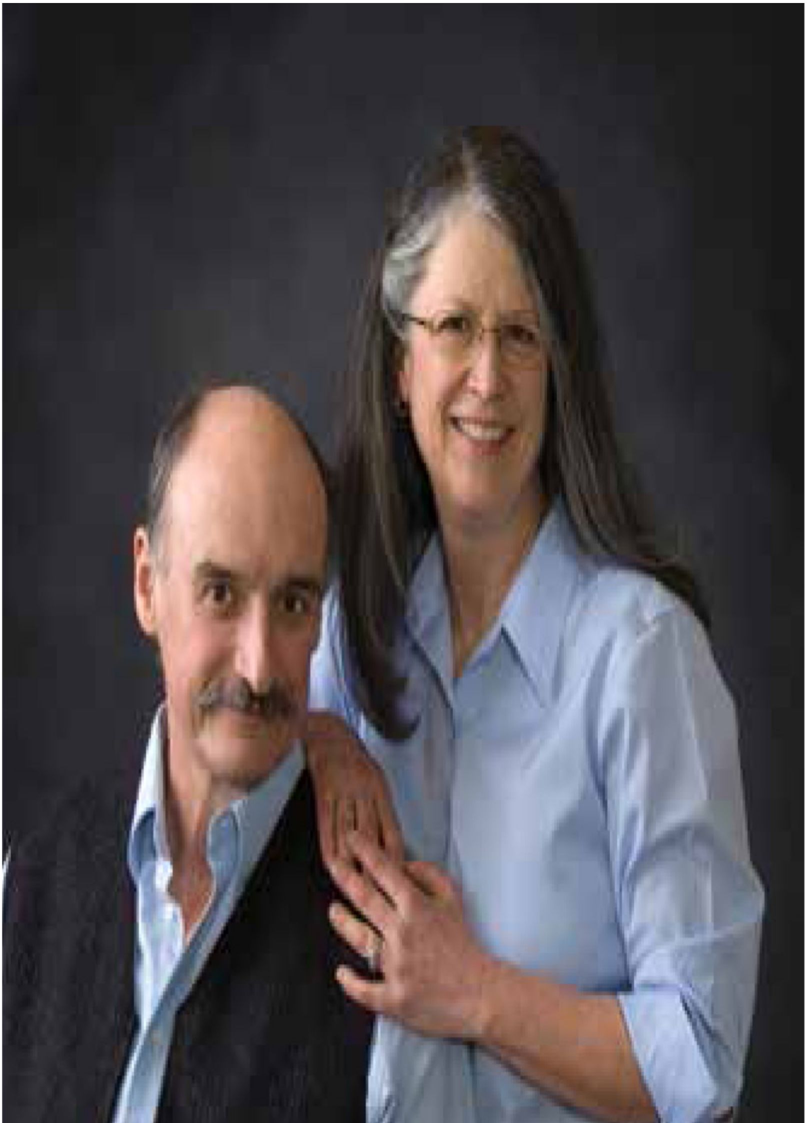
Cheryl Moore-Gough, MS, retired as the Montana State University (MSU) Extension Horticulturist in 2008. While serving in that capacity, she instructed and coordinated the Montana Master Gardener program and was a coauthor for its manual. She is currently Adjunct Assistant Professor in horticulture at MSU, where she teaches Vegetable Production. Additionally, she has taught various undergraduate classes at MSU and has published numerous works alone and with her late husband, the well-known Robert "Dr. Bob" Gough. Together, they wrote four other popular gardening books and over twenty-five Montana Extension publications. Cheryl's recent (2015) release, *The Montana Gardener's Companion,* 2nd edition (Globe Pequot), updates their second collaboration. Cheryl's articles have been published in numerous magazines including *Fine Gardening*, *Rocky Mountain Gardening* (formerly *Zone 4 Magazine*), *Montana Magazine*, *American Nurseryman*, and *Big Sky Small Acres*. Cheryl is an articulate and entertaining speaker, much in demand throughout the western United States.

Cheryl is the technical horticulture editor for *Rocky Mountain Gardening Magazine*, and she has been producing and hosting the Northern News Network's daily radio program *Northern Gardening Tips* since 2004. She has been maintaining landscapes and vegetable gardens in Montana's Gallatin Valley for over 30 years.

In addition to her horticultural pursuits, Cheryl holds a fourth-degree black belt in the Japanese martial art of Aikido and is an instructor at the Bozeman, Montana, dojo.

Robert Gough, PhD, was professor of horticulture and associate dean for academic programs in the College of Agriculture at Montana State University. A former editor of several scientific journals and books and the author of nine gardening books, more than five hundred Extension publications, and articles in such gardening magazines as *Fine Gardening, National Gardening, Zone 4 Magazine*, *Harrowsmith*, and *Country Journal*, he founded and was

the regular host of the *Northern GardeningTips* radio show for 8 years. “Dr. Bob,” as he was known throughout the state, was a fellow of the American Society for Horticultural Science and a teaching fellow of the North American Colleges and Teachers of Agriculture. He passed into the big vegetable garden in the sky in 2011.



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